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# Astounding SCIENCE FICTION

Enough Rope BY POUL ANDERSON

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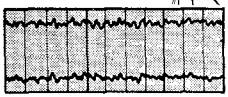

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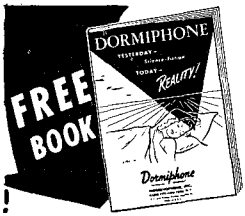


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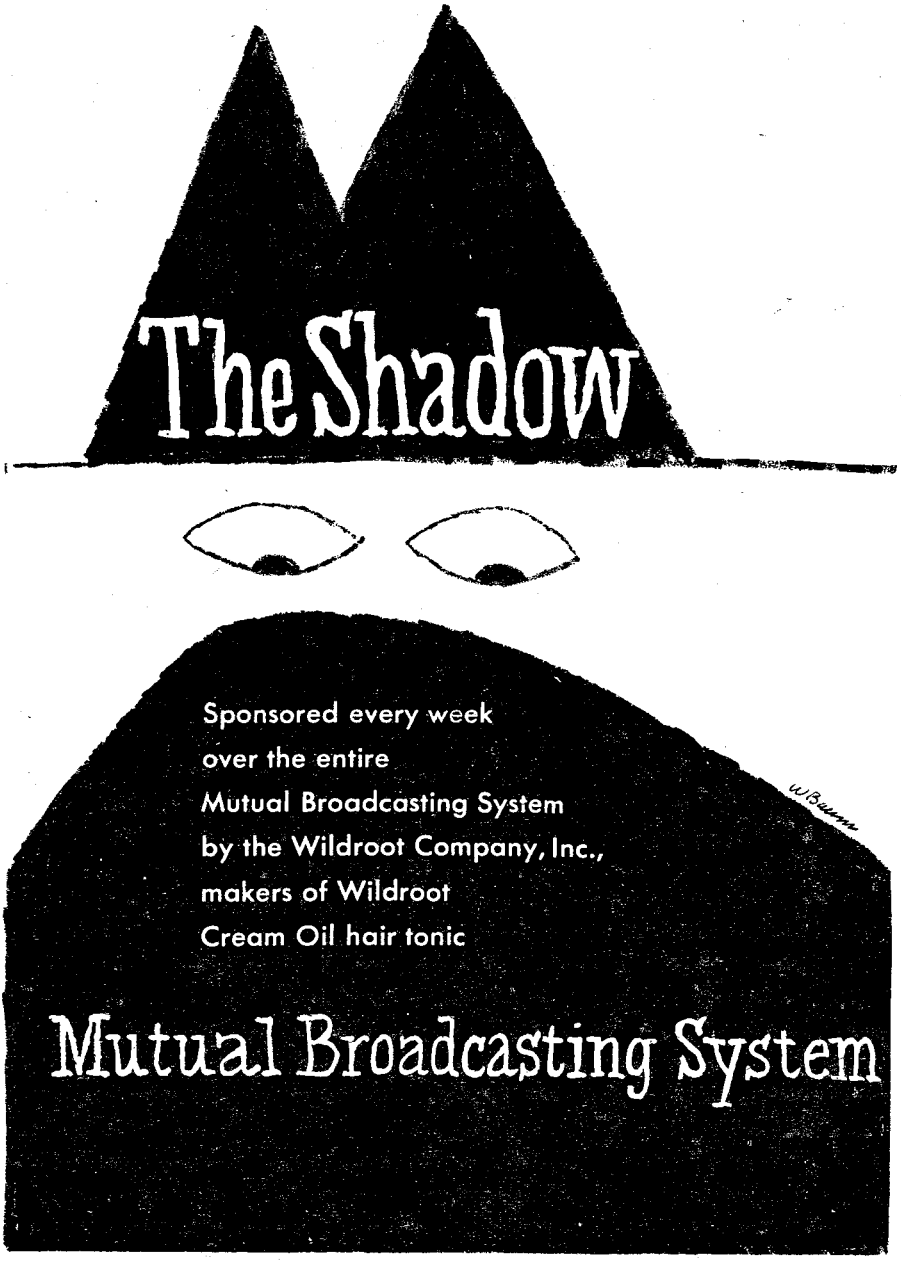


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# Astounding
## SCIENCE FICTION

VOLUME LI • NUMBER 5 **July 1953**

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***COVER BY MILLER • Illustrations by Dreany, Miller, Orban and van Dongen***

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*Astounding* SCIENCE FICTION published monthly by Street & Smith Publications, Incorporated at 575 Madison Avenue, New York 22, New York. Gerald H. Smith, President; Ralph R. Whittaker, Jr., Executive Vice President; Arthur P. Lawler, Vice President and Secretary; Thomas H. Kaiser, Treasurer. Copyright 1953 by Street & Smith Publications, Inc., in the United States and countries signatory to the Berne Convention and Pan American Convention. Entered as Second Class matter at the Post Office, New York, N. Y. Subscriptions $3.50 for one year and $6.00 for two years in United States and Possessions; $4.00 for one year and $7.00 for two years in Canada; $4.75 for one year and $8.00 for two years in Pan American Union, Philippine Islands and Spain. Elsewhere $5.00 for one year and $8.50 for two years. When possible allow four weeks for change of address. Give old address and new address when notifying us. We cannot accept responsibility for unsolicited manuscripts or art work. Any material submitted must include return postage. All subscriptions should be addressed to Subscription Dept., Street & Smith Publications, Incorporated, 304 East 45th Street, New York 17, New York.

*$3.50 per Year in U.S.A.* *Printed in the U.S.A.* *35 cents per Copy*

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EDITORIAL

# "OUR CATALOGUE NUMBER..."

There's a great tendency on the part of a human being to say "It always seemed to me . . ." or "I never did believe that . . ." or the like. It's self-evidently true that the above statements cannot be true of any individual, in any instance whatsoever—not in the sense implied by the individual. Since no individual has existed forever, "always" is inherently inapplicable. Since no individual carried on active philosophical evaluational processes at birth, or immediately thereafter, "always" in the sense of "as long as I have existed" is never applicable.

But we're so ready to pretend that we haven't changed! The basic implication of such statements is simply "I am as I have been and as I will be . . . and furthermore, I'm right, have been, and will be."

As a long-time science-fictioneer, I run into that characteristic in its acute—and acutely irritating—phase. The fellow who "knows" that science fiction is nonsense—the one who, in 1941, "knew" rockets larger than Fourth of July fireworks were nonsense, but who, after reading that V-2s were landing one-ton lots of high explosive in London, instantaneously changed polarity, and "always knew" rockets could do that sort of thing. But who, as of 1944, "knew" atomic energy was nonsense—and as of August 8th, say, 1945, "always knew" we could do it.

The "interval of wonder" is astonishingly small in most people. Of course, eliminating it does make one feel smug, well satisfied with one's deep and cogent understanding of all things. But it seems to me you miss a lot of the fun of sensing the change around you! You know, no matter how fast you're going, you have no sense of motion; it's only the acceleration that you can detect. There's no kick to steady motion—the lift and thrill comes in detecting the great driving thrust that produces the change of speed.

A world of no change is boring beyond endurance—yet it seems to me that a lot of people are missing the immense and joyous stimulus of living in a period when the world is changing, accelerating, faster than it ever did before—by a sort of mental blackout. They blank out the acceleration period, like a rocket pilot who passes



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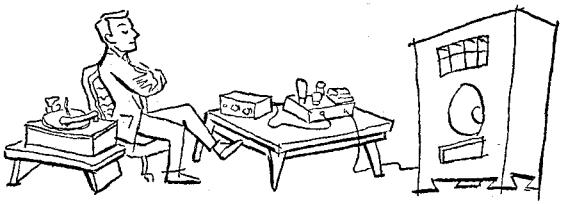
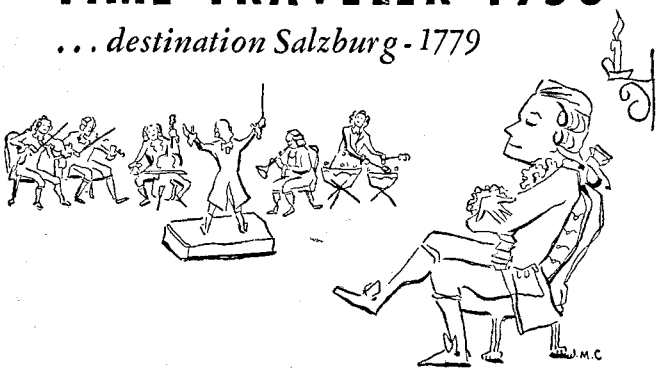


# TIME TRAVELER-1953

*. . . destination Salzburg - 1779*



When young Mr. Mozart played his gay "Post-horn" Serenade in Archbishop Colloredo's palace, the bite of the strings was close and crisp, the horn belled boldly in your ear. You can hear it today like this, too, but not in Carnegie Hall. Mozart, like many another, might almost have written his music to order for today's wonderful, high fidelity *home-music* equipment. Musical time-travel, evening after evening, is here now—for the man who knows how to pick his amplifier, turntable, tuner, pickup, speaker-system and records. The price of the know-how is a subscription to HIGH FIDELITY, the Music Listener's Magazine, with its 32 pages of record reviews, its *tested-in-the-home* reports on new hi-fi equipment, its handsome installation picture-pages and lively feature articles. Current attraction: a comparative report on the entire recorded works of Mozart, by C. G. Burke. Why miss it?

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out during the 8g thrust of the take-off, regaining awareness only *after* the change of speed has been made.

We're only half aware of the immense thrust of civilization toward a higher speed of accomplishment. The change of level is something even the science-fictionally alerted individual can readily miss—because the acceleration is on so broad a scale. The non-science-fictioneer is apt to skip that interval of wonder completely—and it's not too easy for the science-fictioneer to find all of the intervals of wonder, the moments of mental acceleration when we recognize that a vague hope, a half-dream, has become a reality.

Dr. John Pomeroy, who's done a number of articles for the magazine, is an Argonne National Laboratory researcher—and far from sending me tidbits of classified information, has simply kept me aware of the standard catalogues and brochures of the industrial companies that offer various industrial components to interested markets. That supply of catalogues and standard commercial offerings I find far more exciting and intriguing. Talking about going to the Moon, or to Mars is interesting—but what counts is the day someone publishes their annual catalogue offering "our catalogue number . . ." for the four-man scout, satisfactory for Lunar exploratory work, or asteroid prospectors; not recommended for gravitational fields exceeding fifty kilo-newtons."

The booklets Dr. Pomeroy has sent along, during the last few years, are the "our catalogue number . . ." offerings that have reduced the science-fiction of 1940–45 to specific commercial models.

The Collins Radio Company offers, in their catalogue listings, radio receivers and transmitters intended for amateur and commercial installations—and also a cyclotron, standard commercial model, a packaged item ready for delivery and installation on order.

Just about twenty years ago, the cyclotron was the newest and furthest frontier of extremely advanced laboratory research.

General Electric, I understand, has an eighty megavolt betatron they are about ready to offer as a packaged unit for industrial application. Their smaller, twenty-five megavolt model is recommended for X ray quality control inspection on heavy castings and forgings.

I got into theoretical physics back in 1928, because science fiction had convinced me that that was the field wherein the great advances would be made in my lifetime—atomic energy and the like. In 1932, the neutron was discovered, the cyclotron work began, and the real surge to crack the nucleus got under way.

The mass spectrograph was, at that time, a rare and wonderful device, possessed by a few of the most ad-

(*Continued on page 170*)



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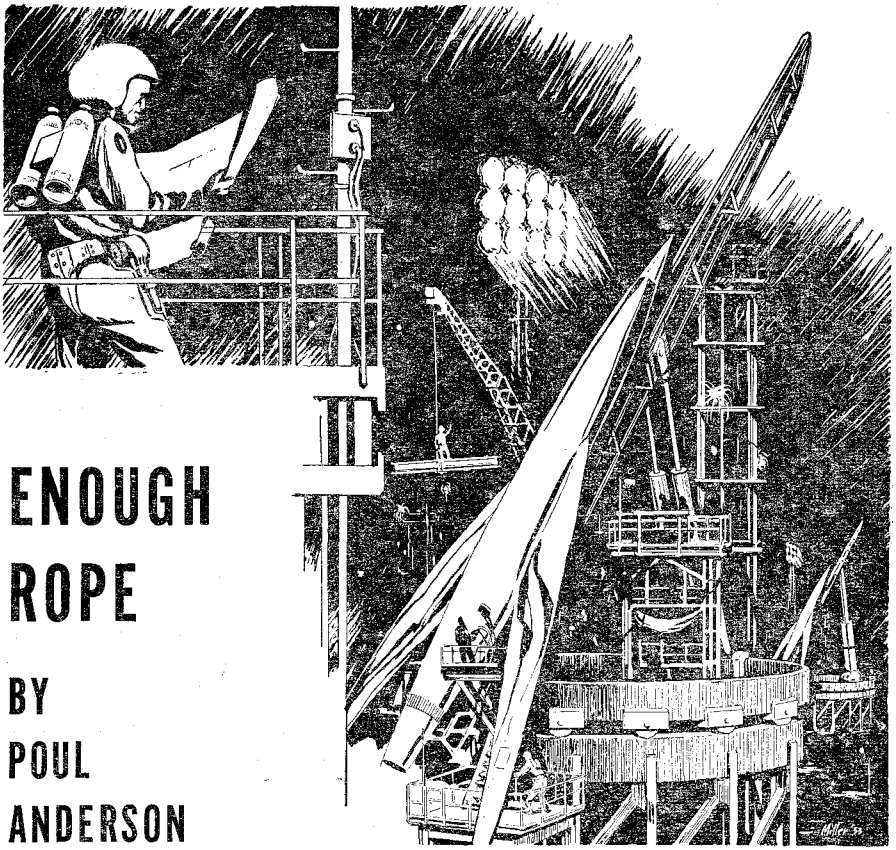

# ENOUGH ROPE

## BY POUL ANDERSON

*There's nothing that so gladdens the heart of a military dictator as the seizing of new territory, planting the flag on new planets.*

Illustrated by Miller

Hurulta, Arkazhik of Unzuvan, fitted his own personality. A magnificent specimen of Ulugani malehood, two and a half meters tall, so broad that he seemed shorter, he dwarfed the thin red-haired human before him. His robes were a barbaric shout of color, as if he were draped in fire and rainbows, and the volume of his speaking made the fine crystal ornaments in the audience chamber tremble and sing, ever so faintly. But the words were hard and steady and utterly cold.



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"Our will in this matter is unshakable," he said curtly. "If the League wants to go to war over it, that will be the League's misfortune."

Wing Alak of Sol III and the Galactic League Patrol looked up into the hairless blue face and ventured an urbane smile. The Ulugani were humanoid to several degrees of classification—six fingers to a hand, clawed feet, pointed ears, and the rest meant little when you dealt with the fantastic variety of intelligent life making up Alak's compatriots. This race looked primitive—small head, beetling eyebrow ridges, flat nose and prognathous jaw—but inside, they were as bright as any other known species.

Too bright!

"It would be straining the obvious, your excellency," said Alak, "to point out that the Unzuvan Empire comprises just one planetary system of which only Ulugan is habitable, whereas the Galactic League embraces a good million stars. It cannot have been omitted from all calculation. But I must say that, under these circumstances, I am puzzled; perhaps your excellency would condescend to enlighten me with regard to your attitude on this disparity."

Hurulta snorted, showing a formidable mouthful of teeth. During the years in which Alak, as chief representative of the League and its Patrol, had been visiting Ulugan—off and on—and particularly during the past several months of mounting crisis during which Alak had been here continuously, he had learned to regard the Solarian as a weak, wordy, and pedantic bumbler. Now one huge blue fist crashed into the palm of the other hand and he grinned contemptuously.

"Let us not bandy words," he said. "The nearest border of the League is almost a thousand light-years away, which would make your lines of communication ridiculously long if you tried to attack. Also, in spite of this distance, we have had our own agents in your territory for years. We know that the temper of the League population is . . . well, let us not say decadent, let us be kindly and say pacific. It would not react favorably to a war which could only mean expense and grief for it. Moreover, the Patrol is a minimal force, designed merely to keep order within the bounds of the League itself. Policemen! We have built up a *war* machine."

He shrugged massively. "Why go on?" he rumbled. "It is only our intention to claim the natural rights of Ulugan. You go your way, we will go ours; we do not wish to fight you, but neither do we feel bound to respect the morals of an altogether different civilization. You can, at best, only be a nuisance if you try to stop us; and if the nuisance becomes too great, we are not afraid of fighting a thousand-year war to exterminate it. We are a warrior race and you are not: there is the essential difference, and mere statistics will not change it."



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He sat down behind his desk and fiddled absently with a jeweled dagger. His voice was remote, uninterested. "You may inform your government that Ulugan is already commencing the occupation of Tukatan and the other planets in its system. That is all. You may go."

To dismiss an ambassador thus was like a slap. Alak had to fight himself for an instant before self-control came. Then his gaunt sharp face smoothed itself out, and his tone was unctuous.

"As your excellency wishes, so be it. Good day."

He bowed and backed out of the magnificent room.

Scene: An upper office in the League Patrol Intelligence—Sol Sector—building, Britn, Terra. A sparsely furnished room, a few relaxers, a desk, the control-studded board of a robo-file. One wall is transparent, opening on a serene landscape of rolling, wooded hills, a few private dwelling-units, the distant bulk of a food factory. Overhead, the sky is full of white clouds and sunshine, now and then the metal gleam of an airboat. It all seems incredibly remote from the troubled world of Galactic politics.

Characters: Myrn Kaltro, sector chief, a big gray-haired man in the iridescent undress uniform of a human Patrol officer. Jorel Meinz, sociotechnic director of the Solar System, small, dark, intense, conservatively dressed in gold and crimson. Wing Alak, unattached field agent, enough of a dandy to wear the latest fashion in civilian clothes—plain gray and blue. But then, he has been away from home for a good many years.

Background: In a civilization embracing nearly a million separate intelligent races, most of them with independent governments of their own, a civilization which is growing almost daily, it is impossible for even a well-informed administrator to keep track of all significant events. Jorel Meinz has hardly heard the name "Ulugan" before today; now he is being asked to authorize an action which may change Galactic history.

He fumbled out a cigar and inhaled it into lighting. His words were quick, jerky, harsh. "What has Sol to do with this? It's a matter for the entire League Council."

"Which won't meet for another two years," said Kaltro. "As our friend Hurulta well knows. It would take six months just to get a quorum together for an emergency session. Oh, they timed it well, those Ulugani."

"Well, the high command of the Patrol can exercise broad discretion," Meinz grimaced. "Too broad. I don't mind saying I haven't liked all reports of your activities which have come to me. However, in this case —"

"The high command is prepared to act," said Kaltro. "I've contacted all members. Nevertheless, the situation is unprecedented. The Patrol was created to enforce peace within the



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League. Nothing was said about dealing with a power outside it. If we act against Ulugan, we'll be on legally shaky ground, and there may be a day of reckoning which would do a lot of harm. Many local politicians are spoiling to take a crack at the Patrol, push through constitutional amendments limiting its scope—if they can persuade enough beings that the Patrol has become an irresponsible machine capable of starting wars on its own initiative, they may succeed."

"I see. But what can I do?"

"Your influence can swing the Solar Parliament into authorizing the Patrol to act against Ulugan. In effect, Sol will say: 'As far as we're concerned, the Patrol can have emergency powers, and use them immediately.' Thereafter, we'll proceed."

"But one system can't do that. The Patrol belongs to the whole League!"

"Please." Kaltro lifted shaggy gray brows and smiled, creasing his face as if it were a stiff brown fabric. "You're a practical political engineer. You know as well as I do that Sol is still the leading system in the League. If it'll back us, enough other planets will follow that lead to put us in the clear when the business is brought up at the next Council. Technically, it'll be a *post facto* O.K. on what we'll already have done, but that'll suffice. It'll have to!"

"Well—" Meinz rolled his cigar between bony fingers, scowling at it. "Well, all right, I see your point. But you still haven't seen mine. *Why* should I help you take action against Ulugan?"

He held up a hand. "No, wait, let me finish. As I understand it, Ulugan is a one-system empire lying nearly a thousand light-years outside our territorial bounds. It wants to incorporate one other system into itself. The natives of that system object, to be sure, and ask us for help—but the hard-boiled League Patrol is, I am certain, the last organization in the universe to get interested in noble crusades. The operation of crushing Ulugan would be enormously expensive. The logistic difficulties alone would make it a project of many years—even if it could succeed, which is by no means certain. The Ulugani could, and certainly would, retaliate with raids on our territory, perhaps they could penetrate to Sol itself. After all, interstellar space is so huge that any kind of blockade or defense line is utterly impossible. And you know what horror and destruction even a raid can bring, what with the power of modern weapons.

"The League is *not* a nation, empire, or alliance. It was formed to arbitrate interstellar disputes and prevent future wars. Such other services as it performs are relatively minor; and its systems are, politically and commercially, so loosely knit that it could never evolve into a true federal government. In short, it is totally unable to put forth the united effort of a war.



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If Ulugan is as determined as Agent Alak says, it may be able to bring the League to terms even if it is one planet against a million. The League may not feel the game is worth the candle, you see. And the resentment at having been involved in a war of which ninety per cent of its citizens would never have heard before death rained on them from the sky—that resentment could destroy the League itself!"

He put the cigar back to his mouth and blew a huge cloud of smoke. "In short, gentlemen," he finished, "if you want my support for this project of yours, you're going to have to give me a pretty good reason."

Kaltro cocked an eye at Wing Alak. The field agent nodded slightly and took out a cigarette for himself. He waited till he had it going before he spoke:

"Let me recapitulate a little, director. Ulugan is a dense, metallic planet of a red dwarf sun. Terrestroid, which means a human can live there but not very comfortably—one-point-five Terran gravity, high air pressure, cold and stormy. The natives are a gifted species, but turbulent, not very polite or moral, all too ready to follow a leader blindly. Those are cultural rather than genetic traits, of course, but they've been pretty well drilled in by now. The history of Ulugan is one of mounting international wars, which pushed the technological development ahead fast but exhausted the natural resources of the planet. In short, a history not unlike ours prior to the Unification; but they never developed a true psychological technology, so their society still contains many archaisms.

"They invented the faster-than-light drive about two centuries ago and started exploring—and exploiting, quite ruthlessly—the nearer stars. They still had nations then, and quarreling over the spoils led to a slam-bang interstellar war. One nation, Unzuvan, finally conquered all the others and absorbed them into a racial empire. That was about thirty years back. It was shortly thereafter that a long-range exploration party from the League, off to study the star-clouds near Galactic center, chanced on them. Naturally, even though they are remote from our integrated territory, they were invited to join us. All races of suitably high civilization are, and so far none had refused. They did. Quite rudely, too. Said they were perfectly capable of gaining everything we offered for themselves, and be damned if they'd give up any of their sovereignty."

"Um-m-m. Paranoid culture, then," said Meinz.

"Obviously. Well, the League . . . or rather, its agent the Patrol . . . did what it could. Sent embassies, cultural missions, and so on, in the hope of gradually converting them. I've been more or less in charge for the past fifteen years, though of course



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I could only get out there once in a while. Too much else to do. We had no luck, anyway, except—" Briefly, Alak grinned. "Well, we do have an efficient intelligence service."

"Spies, you mean?" asked Meinz impatiently.

"No, never! What, *never?* Hardly ever!" Alak's classical quotation was lost on Kaltro, who merely grunted, but Meinz smiled. "We weren't too interested in the military-political details of Ulugan," went on the field agent cryptically. "Mostly, we studied the neighboring stars. No one could object to scientific study of primitive planets, could they?

"I'll see that you get our complete dossier on Ulugani sociodynamics, but briefly, the set-up is simple. There's a hereditary emperor and a military aristocracy ruling a subservient class of peasants and workers. The aristocracy is hand in glove with the big commercial interests—it's a sort of monopoly capitalism, partly controlled by the state and partly controlling the state. No, that's a poor way to phrase it. Let's say that the industrial trusts and the military caste together *are* the state. The supreme power is, for all practical purposes, lodged in the Arkazhik, a kind of combined premier and war minister. Right now he's one Hurulta, an able, aggressive, ambitious being with some colorful dreams of glory.

"Very well. Ulugan, under Hurulta, wants to start conquering itself an empire. Specifically, they intend to annex Tukatan, a fertile planet with a backward population. In fact, by now, in the time it's taken me to get here, they have begun doing so. But you know they aren't going to stop there."

"No," said Meinz after a pause. "No, I suppose not." Then, briskly: "But after all, what does it concern us? A thousand light-years away—"

"That thousand light-years is shrinking," said Kaltro. "The League territory is expanding, through exploration, colonization, the joining of new systems. The Ulugani empire will also expand, toward us. Our analysts estimate that in a mere two hundred years, there will be contact. You know that an interstellar civilization can't be big merely in space; it has to be big in time, too. We have to think ahead."

"Um-m-m—" Meinz rubbed his chin.

"My guess is that if we don't stop Ulugan now, we won't even have those two centuries," said Alak. "They're spoiling for trouble. A real war would unite their still new empire like nothing else."

Meinz nodded. "A good point. But *can* you stop them? To try and then fail would be—catastrophic."

"We can only try," said Kaltro gravely. "I won't hide from you that the situation is, well, precarious. But I don't see how we can afford not to try."

"Still . . . war—" Meinz twisted



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his mouth, as if it held a sour taste. "The ruination of planets. The killing of a billion innocent civilians to get at a few guilty leaders. The legacy of hatred. The corrosive effects of victory on the so-called victors. The Patrol has always existed to prevent war. If it instigated one—"

"Our intention," said Kaltro, "is to stop Ulugan without starting a war."

"How?"

"I can't tell you that. We have to have our secrets."

"And if you do provoke them into declaring one—?"

Alak shrugged. "That," he said, "is the chance we have to take."

"I warn you," said Meinz, "if you get us into real trouble, the Council will have your personal hides."

To that, neither of the Patrolmen replied.

Presently the administrator left. He took with him a bulky file of reports and sociodynamic calculations, and he gave no definite promises. But Kaltro nodded gravely at his agent. "He'll agree," he said.

"He'd better," said Alak. "I tell you, the situation is worse than I can describe. You have to be on such a planet and *feel* the hate and tension building up. Like . . . well . . . it feels sticky. You want to go wash yourself."

"Can you handle the operation?" asked Kaltro. "I'll have to stay behind to fend off outraged citizens."

"I can try," said Alak. There was a bleakness on his lips.

"And look, Wing," said Kaltro, "this is an unprecedented situation, I know. We're acting outside the League, and you might feel free, in real emergency, to violate the Prime Directive. Don't."

"I know," said Alak. "Any Patrolman who does—mnemonic erasure and cashiering from the service. No reasons or excuses accepted. It will be observed in this operation, too. Even if it costs us the war."

He left after a while, to begin on the mountain of paper work which is the essence of a large-scale mission. Not bureaucratic red tape, but necessary organizational detail, and nothing glamorous about it. Nothing of jackbooted heroes, roaring warships, and flaming guns.

But then, the League Patrol had little to do with such matters anyway. They who would end war cannot resort to it themselves, or the injustice, butchery, and waste of it will provoke a hatred that must finally destroy them. The Patrol cultivated a wholly fictitious reputation as a terrible enemy, it cooked news releases about its battles and it maintained a number of impressive fighting ships. When sweet reasonableness failed to enforce the arbitration of the League, the Patrol used bluff; when that failed, it used bribery, blackmail, fomented revolution, any means that came to hand. But always and forever it held



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by the Prime Directive which was its own most closely watched secret.

*Under no circumstances whatsoever may the Patrol or any unit thereof kill an intelligent being.*

A thousand warships lanced through an interstellar night. In their van were the scouts, flanking them were the cruisers, riding magnificently at their center were the monstrous dreadnoughts each of which could annihilate all life on an ordinary-sized planet. They convoyed another thousand noncombatant vessels—transports, supply craft, flying workshops. Behind them lay the stars of the League, lost in a cold glory of constellations; before them were the swelling suns of the loose cluster holding Ulugan.

The task force found the particular star it was looking for, a yellow dwarf some ten light-years from Tumu—which is simply the Unzuvani word for "sun"—and took up an orbit around the clouded second planet. Scouts dropping down through the atmosphere used infrared scopes to see through the mists and the hot, spilling rains; geosonic probes tested a thousand kilometers of swamp and jungle and sullen tideless ocean before reporting a stable surface. Then the big workships began landing.

Wing Alak stood in the phosphorescent twilight of the sixth day, looking at the labor that went on around him. Blasters had driven back the jungle, exposing a raw red scar. Now, under the white glare of floodlights, robotracs moved ponderously back and forth, laying the foundations of a landing field. He could not see through the dimness and the acrid mists to the prefab barracks which housed his workers.

The planet was humanly habitable—just barely. Alak's clothes hung wetly around him and he cursed in a tired voice and wished it weren't too humid for him to sweat. The ceaseless thin buzz of the sanitator about his neck, destroying air-borne molds and bacteria that would otherwise soon have destroyed him, was in a fair way to driving him crazy. *And to think*, he reflected in one corner of his soggy brain, *I could have been a food factory technician at home.*

The scaly, tentacled Sarrushian Patrolmen who made up most of his gang sloshed happily through the muck. This hellhole was almost like their own planet. Not quite—there were some dangerous animals around, you could hear them stamping and roaring out in the fever-mists. And a weird sort of tree that shot poisoned thorns had killed two of his men already.

*Won't those stupid Ulugani ever catch on?*

It was no coincidence that the message should have come just then, for Alak had had few other thoughts since he first landed. The lean, beak-faced Karkarian who was his chief aide came



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from the communications shack and saluted, awkward in the space armor which was necessary for him here. His voder spoke tonelessly: "Subspace call, sir. From Tumu."

"Oh, good!" Alak felt too miserable to do more than nod, but he followed the tall metallic shape with a tinge of energy. It began to rain, and he was soaked before he reached the shack. Not a very dignified spectacle for the eyes of the Ulugani in the screen.

He sat down and ran a hand through his fiery hair. That face—yes, by the First Cause, it was General Sevulan of Hurulta's personal staff; he'd met him a few times. Mustering all his cheerfulness, he said: "Hello." That was an insult in itself.

"Are you in charge of this expedition?" snapped Sevulan.

"More or less," said Alak.

"I demand an immediate and official explanation," said the Ulugani. "A scout ship noticed radiations and investigated. You fired on it, though it got away—"

"Too bad," said Alak, though the fire had missed by his orders.

"That is an act of war in itself," rapped Sevulan.

"Not at all," said Alak. "This is a military reservation. Your scout probed in despite radioed orders to stop."

"But you are building a military base—on Garvish II!"

"That is correct. What of it?"

"Garvish is—"

"Unclaimed territory," said Alak coldly. "If Ulugan can take over Tukatan against the natives' will, the League can surely annex an uninhabited planet."

"You are within ten light-years of Tumu. My government must regard this as an unfriendly act."

"Well," said Alak, "your government hasn't been exactly friendly toward us, you know. We're just taking precautions."

"This is an ultimatum," said Sevulan. "If the subspace radio would reach so far, we would call the League secretariat directly, to give it. As it is, I am delivering it to you. If you do not evacuate Garvish at once, Ulugan will consider your aggression a cause for war."

"Now look—" began Alak.

"A task force is on its way to force your evacuation, if you will not go peacefully," said Sevulan. "Take your choice."

Weakness flitted across Alak's well-trained features. "I . . . I am really not given such responsibility," he said slowly. "You must allow me time to communicate with my government—"

"No!"

"Well—"

"You have my message," said Sevulan. The screen blanked.

Alak stood up, hugged his aide, and danced around the shack.

Hurulta the Arkazhik leaned over his desk as if he meant to attack



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Sevulan. Then, slowly, his great fists unclenched and he sat back.

"They were gone, you say?" he repeated.

"Yes, lord," said the general. "When our task force landed, the planet—the whole system—was abandoned. Obviously they took fright when they realized our determination."

"But *where* did they go?"

Sevulan permitted himself a shrug. "A light-year is too big to imagine," he said. "They could be anywhere, lord. My best guess is, though, that they are running home with their tails between their legs."

"Still—to abandon a base which must have cost an enormous effort and sum to start—"

"Yes, lord, it was astonishingly far advanced. They must have employed some life-form adapted to Garvish II conditions as workers. They do have that advantage: among their citizens, they can always find a species which is at home on any possible world." Sevulan smiled. "I suggest, lord, that we complete the base ourselves and use it, since they were obliging enough to do all the real labor."

Hurulta stroked his massive chin. "We have no choice," he said thinly. "If we don't hold that system, they may come back any time—and it is dangerously close to our home, and as you say their men can function better there than ours." He muttered an oath. "It's a nuisance. We need most



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of our forces to complete the conquest of Tukatan in a swift and orderly manner. But there's no help for it."

"We were going to take Garvish eventually, lord," said Sevulan respectfully.

"Yes, yes, of course. Take this whole cluster—and after that, who knows how much more? Still—" Being a realist, Hurulta dismissed his own annoyance. "As you say, this will save us time and money in the long run."

"I—"

Sevulan was interrupted by the buzzing of the official telescreen. Hurulta switched it on. "Yes?" he growled.

"General Ulanho of Central Intelligence reporting, lord."

"I know who you are. What is it?"

"Scout just came in, lord. The Patrol is on Shang V. Apparently they're building another base."

"Shang V—"

"Twelve-point-three light-years from here, lord."

"I know that! Stand by." Hurulta switched off again. There was something of a giant dynamo about him as he swung on Sevulan.

"What sort of planet is this Shang V?" he snarled.

"Little known, lord," faltered the officer. "A big world, as I recall. Twice our gravity, mostly hydrogen atmosphere—storms of unparalleled violence, volcanic upheavals, a hell planet! I don't see how they would dare—"

"They must be relying on sheer audacity," snapped Hurulta. "Well, they won't get away with it! No ultimatum this time—no message of any kind. You will organize a task force to go there at once and blow them off it!"

The Arkazhik was in an ugly mood, and his subordinates tried to make themselves invisible as he stamped past them. But then, the whole planet was foul-tempered and jumpy. The Garvish and Shang operations had been—still were—messy and costly enterprises which completely disrupted the schedule for Tukatan. That the Patrol fleet had been gone when the Ulugani arrived at Shang, saving them a battle, was small consolation, for it meant that the enemy was still at large, he could strike anywhere, any time, bringing death and ruin out of the big spaces. That meant an elaborate warning system around Tumu, tying up hundreds of thousands of trained spacemen; it meant the inconveniences of civilian defense, force-screens over all cities, transportation slowed, space-raid drills, spy scares, nervousness among the commoners that was not far from exploding into hysteria. It meant that the unrewarding Shang System must also be garrisoned, lest the Patrol sneak back there. It meant irritation, delay, expense, and a turbulent cabinet meeting in which Hurulta had needed all



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his personality to control the dissatisfied members.

He took a grav-shaft now, dropping through many levels to a corridor hewn out of the rock below the capitol. Along this he stalked, the boots of his guards slamming a hollow rhythm back from the walls, until he came to a certain door. This he entered, to find a colonel of Intelligence seated among his instruments. The colonel bowed low. The little being in the chair merely cowered.

"What planet is this from?" grunted Hurulta. "Nobody told me that."

The small one spoke up in a fluting voice that could not hide his terror. He was a skinny, four-armed, greenish being, with a bulging-eyed head that seemed too big for his body. "Please, lord, I am from—"

"I didn't ask you," barked Hurulta, snapping at him. The oversized head rocked back on the spindling neck, and the prisoner began to cry. "Well?"

"From Aldebaran VIII, lord," said the colonel. "A League planet. His name is Goln, and he is a trader who has operated in this sector for a number of years. We pulled him in, together with all other aliens, according to your orders, lord, two days ago. No physical duress was necessary—in panic, he submitted to the usual truth-finding procedures. It turned out that he is a Patrol agent."

"That much I have already been told," snorted Hurulta. "What of it? Why should that concern me? He hasn't learned anything of value, has he?"

"No, lord, not about us. He was a trader too, as he claimed. He merely reported to Wing Alak from time to time, telling him whatever he had learned anywhere. Under our questioning, he revealed a distinct impression that Alak is interested in Umung."

"Umung . . . hm-m-m- . . . the insectiles, aren't they? About thirty light-years off, on the edge of our cluster."

"Yes, lord. He has traded with them for many years. They are a completely organized race, with little individual personality, but the collective intelligence is high. They are also, perhaps, the most skillful workers in the galaxy."

"Yes. It comes back to me now. Did Alak intend to organize them against us?"

"Not as far as this Goln knows, lord. They are totally unwarlike, have too little initiative to make good soldiers. Goln's impression is that the Patrol would like to deal with them, secretly, trading raw materials difficult to obtain on their world for finished products. That would, obviously, simplify the enemy supply problem."

"So . . . it . . . would." Hurulta stood in thought for a moment. Then, whirling on Goln, he made his voice a roar: "All right, scum, how well do you know Umung?"

The Aldebaranian shrieked in utter panic. When he found his voice again,



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he gasped: "Well, most excellent lord. I know it w-w-well—"

"You'll obey us and be rewarded, or you'll be pulled apart cell by cell. Which shall it be?"

"I . . . obey, my lord. The ps-s-s-sychomachines w-will show how well I m-mean to obey—"

"Good. I want you to prepare a dossier on Umung. Use the machines to help you remember everything. Correlate it with all information available in Intelligence files. Submit the complete report to me within an eight-day."

"I . . . I will try, l-lord—"

Hurulta turned back toward the door. No one dared speak to him as he went down the corridor, but his mind was busy.

Umung—yes. It had real possibilities. From all he had heard of it, Umung was a treasure chest. He had to prevent Alak's using it, of course—

But the Patrol! As long as they were in this vicinity, he could not declare war on the League. That might be just the excuse they wanted. He'd fight them if he caught them, but until then it was safer to wait, consolidate his victories.

But it wouldn't take much to occupy Umung. Not if its natives were as docile as all reports had it. And then he could show some real progress to those fat money barons. Already the war would have begun to pay off, and they'd support him in further schemes, let him build up his own power and prestige until the day he turned on them and broke them.

Umung, yes. By all the hells, yes!

Imagine a creature somewhat like an ant—only in general outline, to be sure. It stands a meter tall on two horny legs whose cilia, rubbed together, are its voice organs. There is one pair of tentacles, ending in supple boneless fingers; above them are the true arms, and there is a small stalk on the wrist of each arm holding an eye with microscopic vision. The head is faceless, little more than a set of jaws and a pair of larger eye-stalks for normal seeing. The creature is utterly obedient to the mass-mind of its hivelike community, a patient, tireless, delicate worker. Apart from food and reproduction, its only need is work. Once you have persuaded the mass-mind—embodied in the queen—that it is to its advantage to do as you say, a hundred thousand little brown artisans are ready to slave to the death for you.

Umung is not a large planet. Its atmosphere is thin and dry, its landscape mostly dreary plains. The Ulugani soldiers stationed there grumbled about its dullness. But not many were needed, and soldiers have always complained; it is a healthy sign.

Technicians were required in large numbers, to educate the Umungi in the use of machine tools. But the hive dwellers learned fast. Goln of Aldebaran was invaluable, he knew the ins



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and outs of native ways. Before long, a good part of the entire planet was ready to start producing for Ulugan.

It produced!

"All right, colonel, don't just stand there! Give me your report."

"If it please you, lord, my scout squadron was investigating the Junnuzhik System as per orders—"

"I know! We have to watch every planet of this cluster now, we never know where the Patrol may sneak in next—Well, what is it? Don't tell me they're trying to build another base!"

"No, lord. Our intelligence unit captured some leading natives of Ilwar for questioning—"

"Ilwar! What do you mean? I can't remember every stinking native name for every worthless little area of a thousand inhabited planets."

"The world is Junnuzhik III, lord, the only inhabited one in the system. The natives are centauroids—big scaly fellows, beaked heads, crests—Oh, yes, I see that my lord remembers now. Well, Ilwar is the leading nation on the planet. They've attained a petroleum technology, are pretty good metallurgists, and so on. Under pressure, it was found out that the Patrol has been dickering with them. Wants them to supply several million troops, presumably for an invasion of our planet."

"Patrol have any luck?"

"Well, lord, the natives are thoroughly anti-Ulugan. They assume that if we aren't stopped, we'll conquer them."

"True enough. But . . . oh, blast and damn! We'll just have to take over the planet."

"They're tough warriors, lord."

"I know. And occupying a whole planet is a major operation. But we can't simply sterilize; we'll need it ourselves in the long run. And we must take over the entire world now, colonel. At the very least, we must garrison thousands of key points, or the Patrol ships can simply sneak in and pick up their recruits. At this time, too!"

"Lord—"

"Shut up! File a complete report. Now get out of here. Hello, hello, give me the General Staff building . . . Commander Tuac? Ready your planners, boy. We're going to invade still another world."

"Tuac? Listen and obey."

"Yes, lord."

"You know the planet Yarnaz IV?"

"Hm-m-m . . . let me think, lord."

"Don't. You're not capable of it—you and your planning section!"

"Lord, how could we know the Ilwari would be such guerrilla fighters? Even under extreme difficulties, we're carrying on the conquest—it's just going more slowly than we had anticipated. If we could only have more troops, more supplies—"

"Shut up, I said! We haven't even finished with Tukatan itself, thanks



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to that Patrol. Junnuzhik will have to make do with what we can spare. Now listen, or I'll have your head. Yarnaz is a red dwarf sun about fifteen light-years from Tumu. Its fourth planet is trackless desert, poisonous air, venomous life. Nevertheless, our checkup reveals that the Patrol has been there. Not a base. They've been mining near the equator. *Why?*"

"Lord, I can't say. Unless they wanted supplies—fissionables, perhaps.—"

"I checked up on that, idiot. Yarnaz IV is about as poor in natural resources as empty space itself."

"Could it be a camouflage, lord? A device to divert our attention from their real activities?"

"It may well be. But, we don't *know!* The Patrol seems to have studied the primitive planets of our cluster better than we have ourselves. Furthermore, they have the natives of a million worlds to choose from in making up their crews. Doubtless there is at least one race in the League to whom Yarnaz IV is just like home. We can't know where their real advantage lies."

"Well, lord, it . . . it looks as if we'll have to establish garrisons there."

"I'm glad you've seen that much. How soon can you send a force?"

"The planning— Lord, we're getting bogged down. There's just too much to handle. Even one world is a major problem in strategy, tactics, logistics—"

"Nevertheless, Yarnaz IV shall be occupied within one month. Or do you want your head adorning a pole in Market Square?"

Fear was cold along the spine of Hurulta as he looked at the being in the cage.

It seemed harmless enough—a small kangaroolike mammal, with big ears on its round, blunt-muzzled head. The sensitive four-fingered hands spoke of intelligence, the basic tool-making ability. There was no menace in the soft brown eyes.

Nevertheless Hurulta was afraid. It took all the discipline he had to face that creature and hold his own visage expressionless.

"It was caught on the fringes of Dengavash City, lord, just after the riots there," said the police officer. "Obviously it was the thing responsible. It creates an aura of terror."

Hurulta forced his tongue to shape coherent words. "Where's it from?"

"We checked up, lord. It's from Gyreion, as the explorers have named it—a planet not unlike ours, on the fringes of our cluster. This is one of the natives. They haven't been studied much, but seem to be a timid paleolithic race. Telepaths, though."

"I . . . see. And when they're frightened, as must happen rather easily, they radiate the fear-impulse and our minds pick it up."

"Yes, lord. We think a Patrol



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sneak-boat must have taken a few and dropped them here on Ulugan. We'll soon round up the others and we'll be sure."

"Um-m-m." Hurulta's heavy blue face contracted in a scowl. It was hard to think clearly, when he had to keep fighting down the germ of panic that screamed far down within him. "Yes. A good idea. But quantitatively insufficient. The Patrol can't possibly smuggle enough of them here to make any significant trouble."

"No, lord. Just nuisance value. Like everything they've done so far, isn't it . . . if I may make bold to speak."

Hurulta turned and walked out of the room. Gyreion—hm-m-m. A tough nut to crack, that world—but worth while. If enough of those hoppers could be turned loose on an enemy planet—why, it was the ultimate in psychological warfare!

The League planets—a decadent bunch. They couldn't stand up long to such fear. They'd be ready to surrender to the first warship that came along.

Meanwhile, it was necessary to cut off the Patrol's access to Gyreion. Wouldn't take too big a force for an effective occupation; the natives weren't fighters. Once their fears had been calmed, they would be quite harmless—to Ulugan.

*This time, my friend,* he thought with a savage glee, *this time you've finally overreached yourself!*

Wing Alak was getting bored. He didn't have much to do now but sit in his flagship and read the reports of his scouts and radio monitors. He welcomed the newcomer who had arrived with the last courier ship from home, even if it did mean a struggle.

Jorel Meinz entered the vessel and followed Alak down a long corridor. His nose wrinkled a bit at the many odors that filled it. The crew of the battlewagon all came from terrestroid planets, but they had their characteristic smells and their own styles of cooking; no ventilation system could quite purify the air. But then, he reminded himself, a Terran probably didn't smell any better to them.

Alak's cabin was a spacious one, sybaritically furnished. One large viewport showed the eerie hugeness of space, the rest of the room seemed devoted to human comfort just to offset that chilling spectacle. The Patrolman waited till he was alone with his guest before pouring out drinks.

"Scotch," he said. "It may not mean much to you, but out here it's a real luxury."

"The Patrol seems to do itself well," observed Meinz.

"Quite," nodded Alak. "When you're out for months or years at a time, surrounded by total alienness, every comfort means a lot. It's pure superstition that the being with a low standard of living is hardier." He lifted his glass and sipped appre-



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ciatively.

"Are you sure you won't be found out here?" asked Meinz. "I imagine the enemy is ripping holes in space, hunting for you."

Alak grinned, which made him more than ever resemble a fox. "No doubt they are," he said. "The harder they search, the better I like it, since it means a useless waste of their time, men, and matériel. Several thousand cubic light-years makes a pretty effective concealment. Anyway, if by some freak they should blunder across us, we need only run for it."

Meinz scowled. "That's what I'm here about," he said brusquely.

"Aren't they satisfied at home with my conduct of the operation?"

"Frankly, no. Now I'm on your side, Alak. I was the one who pushed that approval through Parliament. But that was almost a year ago, and so far you've reported no results at all. Your dispatches have been so much meaningless verbiage. Finally certain political groups hired an investigating force of their own. They sent out observers—"

"A wonder they weren't nabbed. Hurulta has an efficient Intelligence Service and Secret Police."

"Well, they weren't. They saw enough to send them hightailing back home, and the stink it's raised on Terra—"

"Ah-hah! That explains it. Hurulta must have foreseen that result and let the observers do as they pleased. He's a canny lad, that old blueface."

"Well, you must admit there's some justification for the complaints," said Meinz with a hint of bitterness. "The authorization was of doubtful legality in the first place, and could only be justified at the next Council meeting if there were solid results to show. Instead, you've dawdled out here, skulking I might say. You haven't fought one battle, not so much as a skirmish. You've let Ulugan occupy no less than seven planets besides Tukatan—"

"At last reports, it was about twenty," said Alak blandly. "We've got them scared, you see. They're grabbing everything that might conceivably be of value to us."

"In other words," said Meinz, "you're pushing them in exactly the direction they want to go."

"Correct."

"Now look, Alak. I came out here myself, and it's a long troublesome journey, to get your side of it. I have to tell them something at home, or they'll pass a recall order in spite of everything I can do. Now I'm not even sure if I would resist such a move."

"Give me credit for some sense," urged Alak. "I can't tell you everything. The real reason why we operate this way is a Patrol secret. Let's just say, which is true enough, that outright war is cruel and expensive, and that I don't even think we could win one."



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"But what *are* you doing then, man?"

"Just sitting here," laughed Alak. "Sitting here drinking Scotch, and letting nature take its course."

The medical officer halted at the entrance to the tent. The steady, endless rain dripped off his shoulders and made a puddle about his muddy feet. By the one glaring lamp inside, he noticed that the fungus had begun to devour this tent, too. It would be a rag before the eight-day was out. And you couldn't live in the metal barracks left by the Patrolmen—they were bake-ovens, and air-conditioning units rotted and rusted too fast to be of help.

He saluted wearily. The commandant of Garvish Base looked up from his game of galanzu solitaire. "What is it?" he asked listlessly.

"Fifteen more men down with fever, sir," said the medical officer. "And ten of the earlier cases are dead."

The commandant nodded. Light gleamed off his wet bald head. The blue face was haggard, unhealthily flushed, and the smart uniform was a sodden ruin. "The sanitators don't work, eh?" he asked.

"Not against this stuff, sir," said the doctor. "It seems to be a virus which isn't bothered by the vibrations, but I haven't been able to isolate it yet."

"We just aren't built for this climate." The commandant wagged his head, and one shaky hand reached for a bottle. "We're cold-world dwellers."

A beast screamed out in the jungle.

"Poison plants got several more this eight-day," said the doctor.

"I know. I've begged and pleaded with headquarters to send us air domes and space armor. But they claim it's needed elsewhere."

A faint hope flickered in the medical officer's eyes. "When that planet Umung really gets to producing—"

"Yes, yes. But we'll probably be dead then, you and I." The commandant shivered. "I feel cold." His voice was suddenly high and thin.

"Sir—" The doctor took a nervous step forward. "Sir, let me look at you—"

The commandant stood up. For a moment he leaned on the table, then something buckled within him and he went toppling to the floor.

There was forest, endless forest, and beyond it the plains and mountains and sea, and all of it was full of death.

The Patrol wound slowly through the woods. Every detector they had was straining itself—metal, mental pulses, the thermal radiation of living bodies. But still eyes were restless, shifting under the big square helmets, and hands strayed nervously toward guns.

In an armored car near the middle of the column, the Ulugani Patrol



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chief was sounding off to his aide. "It's no good," he said. "These Ilwari are just too tough for us."

"They can't stand up to us, sir," said the aide. "Not in open battle."

"And they don't try. What can you do with a people who're willing to scorch their earth and evacuate their own dwellings before we get there? What's the point of silly little actions like this one—going out, burning a city in reprisal, what does the enemy care? It's just a chance for him to harass us some more."

"We'll teach them manners, sir," said the aide.

"Oh, in time, of course. In time. When we get enough troops and supplies here. But curse it, I can't *get* enough!"

An explosion cracked before them. The chief saw three men fall screaming from the grenade. A heavy machine gun began to clatter.

"Guerrillas!" he roared.

He glimpsed the big green forms dashing in out of the brush. They



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could gallop like the wind, those devils, and they could carry as much armament on their backs as a small truck. The war whoop sent a brief tingle of fear along his nerves.

The tanks began to speak, throwing flame and thunder at the enemy. One of the machines was suddenly wrapped in red smoke—a fire bomb. The Ulugani infantry had thrown themselves to the ground and were shooting up at the trampling, yelling centauroids.

"Drive 'em back!" screamed the chief. "Drive 'em back!"

The Patrol did, after a short interval of utter ferocity. But not before a bomb had struck the command car and incinerated its contents.

The colonel looked out of the thick plastic port and shivered. Beyond it, the landscape was one vast gloom. Poisonous mists curled between him and the unseen horizon, like a wall. He thought he could see the sudden red spouting of a volcano, somewhere in the fog. A moment later, the floor quivered under his feet.

"You fool!" he raged. "You utter imbecile!"

The base geologist stood his ground. "We did our best, sir," he answered. "As far as we could tell, the terrain here was stable."

"One whole base has already been destroyed in a quake. Isn't that enough for you?"

The wind slapped monstrously at the dome. They had never seen such gales as blew endlessly across Shang V. A blind whirl of sleet—solid ammonia—hid the outside view.

"Sir," said the geologist, "this planet is utterly crazy. The probes gave readings that on any normal world would mean safe, solid ground."

"Nevertheless, one of our domes has just been cracked open. Every man within it died instantly. You and your team are due for court-martial."

The geologist nodded.

"As the colonel says. But may I suggest that we find another site? This one is obviously dangerous after all."

"And do you realize what it means, in terms of effort and materials, to break camp on this planet?"

"I can't help that, sir. I am officially proposing that we move."

"Headquarters will have my skin, too," said the colonel gloomily. He looked out again at the sinister land. "How could we know? How could anyone have foretold it would be like this?"

*The Patrol knew!* laughed his mind. *They knew! Now all I can do is submit a recommendation that we evacuate. The other commanders here will back me up. But that's an invitation to the enemy to return.*

The floor trembled. He heard a paperweight jump on his desk. Outside, not five meters off, a hole opened in the ground—slowly, hugely, with all the time in the universe to do its work. Fire spumed from it, and magma crawled forth toward the dome.



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The Elgash family had come up the hard way, from the peasant stock of a conquered land; it had been ennobled only fifty years ago. For that, and for its owning the Munitions Trust, Hurulta despised it. But he did not underestimate the being who sat across from his desk. The present Elgash was fat and wheezy and dandified, but there was a hard drive and a cold brain in him.

"I speak for several others, your excellency," he said. "I need not mention their names."

"The money barons," replied Hurulta sullenly. "The industrialists and financiers. What of it?"

"Shall I speak plainly?" asked Elgash.

"Go ahead. We're alone."

"The group I represent is not at all satisfied with the conduct of the war."

"Oh? And you have constituted yourselves the new General Staff?"

"Spare the sarcasm, your excellency. It was understood that Tukatan would be subjugated within six months. Now, after almost a year, we are still fighting there."

"They could be bombarded from space," said Hurulta, "but as you well know, that would destroy the whole value of the planet. We have to go slowly. Then the Patrol appeared to complicate matters."

"I realize all that." The insolence was more marked than ever. "And rather than concentrate on Tukatan and the Patrol, and get them safely out of the way, your ministry has tried to take on the whole star cluster. You have blundered disastrously into planets we hardly knew a thing about."

"To keep the Patrol from using them against us." Hurulta checked his temper. "All right, I admit we've had our troubles. But we're making progress. The over-all timetable for the establishment of our hegemony has been accelerated enormously. In the long run, that will mean a saving."

"Will it now? Even your successes are dubious. Take that forsaken little pill of sand, Yarnaz IV. There's been no trouble in occupying it. But the expense of maintaining bases under such alien conditions is fantastic. The commoners are being taxed to the limit, and your new tax on the leading groups of society is outrageous."

"It has to be done. Or would you rather have the Patrol come in and run things?"

"Of course," said Elgash coldly, "your most inexcusable blunder was the occupation of Umung."

"*What?*" For a moment Hurulta could find no words. Slowly, then, he gulped down his rage, and when he spoke it was with thin precision. "That was the one operation which went off like clockwork. At a negligible cost in men and money, we have already doubled our war production. Inside another year, we can expect to quadruple it."



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"I thought you were a realist, your excellency," said Elgash. "I thought you understood the economic foundation on which the empire rests. Or are you deliberately ruining my class?"

"Are you mad? First you complain about taxes, then when I find a way to increase production, a way that costs us hardly one crown, you—"

"Your excellency, we have only so many soldiers and there is a limit to the amount of war matériel they can use. When Umung is producing all of it, *what will become of Ulugan's factories?*"

Fear.

Shamuvaz, soldier of the empire, looked around him. He moved his head very slowly, lest he see something behind his back. There was only the landscape—distorted trees, murmuring reddish grass, a remote waterfall that echoed the furious clamor of his heart.

He felt ill. He wanted to vomit. Looking at the faces of his companions, he thought that they were impossibly alien. They were evil. They were made evil by the same horror that rode on him, and in their panic they might turn and tear him.

Shamuvaz whimpered, deep in his throat, and thought of his wife and children. They were so far away, so many centuries away, he would never see them again. He would rot on Gyreion, the wind would blow through his ribs and the small beasts of the field would nest in his empty, empty skull.

They said it was harmless. They said it was only that the natives—so thoroughly indoctrinated by the Patrol that there was no dealing with them . . . or was it that, being telepaths, they knew Ulugan meant them for pawns?—the natives were afraid, and you yourself heard their fear. Nothing to it. Ignore it. You are a soldier of the empire, and fear of nothingness is unworthy of you.

Only the generals didn't have to live with fear. They didn't have to torment themselves, night after night, to stay awake, for fear of the dreams; and when they finally did sleep, in spite of everything, they weren't brought up within minutes, screaming. They didn't see their comrades break, one by one, and be sent home muttering idiot words, and wonder when their turn would come.

Fear, panic, terror, blind howling horror. Shamuvaz groaned to himself.

When a hand touched his shoulder, he leaped up, cursing, and spun around. His pistol was out before he saw that it was only Armazan. Armazan had been his best friend once. But you couldn't trust anyone now. Shamuvaz held the gun leveled on Armazan's belly.

"Don't do that," he choked. "Don't ever do that again."

"Listen." Armazan spoke swiftly, a whisper that was blurred with his own trembling. "Listen, Sham, we're meet-



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ing after taps, down by the river. Sneak out of the barracks and join us."

"What, what, what? Go out after dark? You're crazy! This planet has driven you crazy."

"No, not that, not that. Listen, a lot of us have decided we aren't going to take any more of this. The empire can't ask it of us. It's too much. Can't trust those officers. Get them out of the way—a shot in the back, it's easy if we just stick together, and then we can grab the base spaceship—"

Hurulta had been sleeping poorly in the last month, and drugs no longer seemed to whip up his vitality. He clasped a ringing head in his hands and leaned on the desk.

"It's no use," he said aloud. "We'll have to pull out of Gyreion. Every regiment there has been ruined for service. It'll take months to restore them to usefulness."

"But the Patrol, lord—" faltered Sevulan.

"Patrol! We'll maintain a base on the neighboring planet, and a few orbital scouts around Gyreion itself. Should have done that in the first place."

"But then a strong attack could come in, wipe out our forces, take over the whole system—"

"I know. What of it? A chance we'll have to take. If only the busybodies would come out of hiding and fight! It's like shadow-boxing, this."

"Lord, I understand the General Staff plans to overrule you and order the evacuation of Garvish and Shang. They say it's too costly to hold them, they're just consuming men badly needed elsewhere—"

"Don't tell me that!" shouted Hurulta. "I know it, you idiot! I know all of it! The blind, bloody fools! Shortsighted—aaargh!" His fists clamped together. "But by all the hells, we're hanging on to Umung. Let the moneybags squawk. I'll lodge treason charges if they say much more."

The telescreen buzzed. Hurulta flicked a switch, and the excited voice gabbled out.

"Lord, a report just came in from space. Patrol activity around Ustuban VII. They seem to be rendezvousing—"

"Ustuban VII! They can't! It's a giant planet. It's surrounded by a meteor belt. It . . . no!"

"Lord, the report says—"

"*Shut up!* Send me the full report at once." Hurulta whirled on the general. His eyes were feverish.

"Action," he gasped. "I think we're going to see some action. The populace has been complaining about our retreats, have they? Their morale is bad, is it? All right, we'll give them something to talk about. We'll send the fleet and seize Ustuban VII, and just let the Patrol dare try to stop us!"

"Lord, it's impossible," whispered Sevulan. "We're spread so thin already that we could never mount such



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an undertaking. It's just a trick of theirs to lure us out—"

"We'll turn the trick on them!" Hurulta's bellow rattled between the walls. "I'm still the supreme commander here!"

Slowly, as he regarded his chief, Sevulan's eyes narrowed.

"We have, of course, been propagandizing Ulugan," said Wing Alak. "Radio, message-scattering robombs, and so on—the usual techniques. I think we've gotten it across to them that, while League membership means a loss of imperial glories, it means a definite gain in material comfort and security."

"For the commoners," said Jorel Meinz. He was annoyed; three days aboard ship, with Alak engaged in directing some obscure maneuver and parrying every significant question when the two men did meet, had worn down his nerves. "But it's the aristocrats and the industrialists who run things."

"To be sure. However, they aren't stupid. They just need a hard lesson to convince them that imperialism doesn't pay."

"They were all set to make it pay."

"Of course, till we interfered. But as long as there is a Patrol, conquest will mean a money loss. We'll see to that! Once they're convinced that it's to their advantage too to come to terms with us, they'll do it."

"I see your general strategy, of course," said Meinz. "You've led them into taking over one unprofitable planet after another. Except this Umung, now . . . I can't see where that could fail to pay off."

"Oh, that was my proudest achievement," said Alak smugly. "I planned that years in advance. I had a cowardly little part-time agent who got to know Umung quite well. As far as he could tell, I meant to use it for the Patrol's benefit. Ulugan got hold of him, as I thought they would, and learned this. So naturally Ulugan had to grab it first.

"But don't you see, I've studied their economy for years. It's an archaic form of capitalism, like Terra's during the First Industrial Revolution. It depends on buying cheap and selling dear—and it must sell manufactured goods. In short, a colony which can manufacture better and cheaper than the mother country is, in the long run, impossible; it must be abandoned or ruined, or else the homeland's economic system must be changed. After a while, Ulugan's financiers realized that. And they're a powerful element."

He lit a cigarette and leaned back in his chair. "If I might generalize a bit," he said, "history shows pretty conclusively that an empire must form a natural socioeconomic unit if it is to be stable. Most empires of the past grew slowly, by accretion; or if they were conquered fast, they had to be reorganized swiftly. We forced the Ulugani into taking on more real



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estate than they could handle, most of it worse than useless; and we kept them off balance so that they couldn't get a chance to organize it properly. Result—an unstable situation which is now rapidly deteriorating."

"Do we *want* them within the League?" asked Meinz. "They look like a nest of troublemakers."

"They are. But in the long run, they can be integrated. Contact with other cultures will break down their paranoid attitude. Interstellar empires are economically unjustifiable anyway, more of a drain than a gain. If you've mastered faster-than-light travel, you are also able to produce just about everything you need at home, and trade for the rest. They'll come to see that too, eventually."

He glanced at the intercom. "I'm expecting a message hourly," he said. "My last scout ship brought some interesting political news from Ulugan."

"Eh?"

"Play me some chess, will you? I love dramatic revelations. You can allow me this one. It's been a rather dreary year."

It was only half an hour later that the ship's radioman announced a subspace broadcast, Ulugan calling the Patrol command. Alak made a leisurely way to the communications room, letting Meinz jitter behind him.

The blue face in the screen was trying hard to maintain its old arrogance, but not succeeding very well. "Hello, Sevulan," said Alak. "What's new?"

"There has been a change of government in the empire," said the Ulugani stiffly.

"Violent, I'm sure. Did you shoot Hurulta or just jail him?"

"The Arkazhik is—very ill. Frankly, we suspected he was a mental case. His rashness brought on many actions of which the new cabinet never did approve."

"Well," said Alak genially, "if you want to negotiate, here are my terms."

When he had finished, and sent a representative off to meet the Ulugani delegation, he yawned mightily. "I think that's that," he said. "There'll be a lot of dickering, of course, and cleaning up the military forces there will take time. But we've got what we were after."

"You mean—" Meinz chuckled dryly. This success wasn't going to hurt his own career a bit. "You mean you let them give you what you wanted."

"Oh, no," said Wing Alak. "I was the donor all along. I gave Hurulta all the rope he needed."

THE END



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# SOLUTION DELAYED

## BY MARK CLIFTON AND ALEX APOSTOLIDES

*__Before__ you can solve a problem, you must acknowledge the problem exists. To acknowledge it exists, you must acknowledge you don't know the answer. But if you don't know the answer, then how can you solve it . . . ?*

Illustrated by Orban

The offices and buildings of Tech Control were not impressive. Impressiveness was still the prerogative of World Government, Political. Tech Control, the centers of actual world government, seemed to pride itself on offices which remained small, humble, almost shoddy. In that, at least, they were wise. As yet, human nature had not changed. The pomp and circumstance of political control was still mistaken for strength and power by the public. Tech Control was thus left free to concern itself with the things which really mattered.

Nor do tech engineers require gilt and glitter to get their work done. They remain impatient with enormous systems which exist for the sake of their own complexity. Engineers, unlike synthesist administrators, seem to feel it is the bare essentials which count. As such, even the most complex engineering project becomes relatively easy to handle—say such a project as governing an entire world.

Even the Southwestern Division Offices of Tech Control shared the custom of obscurity rather than follow the custom of Greater Los Angeles for the glorification of front. Only two blocks away from the vast buildings of Intersol, manufacturers of interplanetary ships, there on the edge of the Mojave Desert, Div Tech occupied a squat four-story building. It sought no attention, nor got it from the public.

Yet it was from this office that the entire program of colonization of planets and satellites stemmed. In every major city throughout the world there were World Government, Political buildings, with thousands of clerks and administrators to interview the thousands of families who thought



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they might like to colonize—if conditions were made quite comfortable, comparable to those on Earth, you understand. And still more clerks and administrators to answer the hundreds of thousands of questions, feeding the spurious movies and news releases to the general public.

But World Government, Political knew no more what families were finally chosen, or what really happened on the planets than did the general public.

Strangest of all, considering such a thing of tremendous import, there was comparatively little more than apathy. For Earth was a comfortable and comforting place to live. The great problem had been solved. Man was learning to live with himself and took the indolent attitude of an overgrown lazy lad, "Who wants to buck reality when the beds at home are so soft, the food so good, and the treatment so indulgent?" Nor was there anything in the contrived films and releases to excite the spirit of adventure.

Spot checks revealed that, as with the old propaganda films released on TV, ninety-nine and 33/100ths per cent of the people immediately punched irritably at video-control buttons to pick up something interesting instead.

Little of all this filtered back to the squat building of Div Tech, and that which did, received most attention from the heat-control engineer who complained of burning so much paper in his furnaces.

Seeming to match the squat building of Div Tech, and the sparse offices, Business Agent Follette Langley, a man insignificant in appearance, sat behind his desk in an office equally insignificant. With apparent indolence, face tending to flabbiness, hair beginning to thin, eyes mild and expressionless, his attitude toward his visitor was one of patient tolerance. He would waste time hearing his visitor's grievance; but without supporting curves and charts, without math formulae, without trajectories of slide-rule calculated plots, Langley's attitude seemed to imply that the conversation was no more than that—a waste of time.

Arthur Cameron sat in his chair across the desk from Langley, but he was neither relaxed nor indolent. Involuntarily his dark eyes flashed in hostility at the reception he was obtaining. But as with a long line of Labor Relations men before him, when dealing with Business Agents, Cameron kept his voice under control.

"These restrictions, inspections, red tape tie-ups in the selection and training of workers are ruining us," he said forcefully. "You've got a shop steward over at Intersol who thinks he's a dictator. I tell you Langley, it's come to a showdown. Either you get him out of there, or I get out. We can't both be Labor Relations Director. We're simply grinding down to a halt with his constant interference in my



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work."

"Seems to me you've just completed Interplanetary Ship #7, haven't you?" Langley answered mildly. "That doesn't look as if Intersol is grinding to a stop." He took an old-fashioned tobacco cigarette from a case and held the tip of it against an infrared lighter. His entire gesture was one of boredom.

"But in spite of Slater and his spies," Cameron said more bitingly than he had intended. Every time he talked to this man, Langley, he grew furious in spite of himself.

"Slater is all right," Langley said soothingly. "Perhaps a little overzealous at times. He's just making sure that the covenants of Tech Control are not being violated. It would be very simple, you know, for your company to start manufacturing weapons under the guise of something else, or make an undue profit on these ships at the expense of the public."

"Nonsense," Cameron exploded, and leaned forward in his chair. "Do you think we're foolish enough to buck the Union of Physical Scientists? How could we make such things without accredited engineers, your own members, knowing about it? Who would there be to design them? Design the machinery to make them, design the production flow to turn them out, except members of the Union of Physical Scientists? And who would use weapons if we made them? The entire world runs on technology. Nothing can happen in it without the knowledge of technologists, members of UPS. What earthly purpose does it serve to have Slater and his crowd eternally spying, sneaking in microphones, tapping intercom videos, hiding in dark corners—"

"Your sermon is showing, Cameron," Langley said quietly, and made no effort to hide the amusement in his eyes. "Didn't you once write a book on human tensions?" he switched the topic suddenly. "And wasn't it your central theme that there was a productive and self-satisfying place for every member of our society, regardless of the warp of his tensions?" He sat up a little straighter and seemed to take a greater interest in his theme.

"It has been better than fifty years now since UPS delivered its ultimatum. You remember that ultimatum, Cameron. Every schoolboy knows it. No technologist will work on an implement of war. No technologist will work on a project where graft for a few men will be at the expense of the many."

"I'll not deny it was a great dream," Cameron conceded. "In principle."

"Not too difficult to achieve, either," Langley said reflectively. "No more difficult than the early days of trade unions generally. Easier, in fact. What uneducated and often unthinking men could do was not too difficult for the trained technologists."

"Incompatible though, with the



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very training and education they had," Cameron commented.

"Oh no. We had just one hurdle to overcome. Prior to UPS it was the contention of technologists throughout the world that theirs was not the field of sociology, that they had no responsibilities to mankind for the use to which their work was put. Until they realized, almost simultaneously all over the world, that sociology is every man's job; that man could never solve his Great Problem by not letting his right hand know what his left hand was doing; that the making and using of an implement is all one continuous flow of cause-effect-sequence, and cannot be separated by any arbitrary line of responsibility evasion. When that hurdle was passed, UPS became a spontaneous reality." He paused significantly, as if there were no more to be said.

"I'm not so sure it was a wise thing," Cameron said slowly.

"Not wise?" Langley asked curiously, and leaned forward. "Not wise to take the simplest, most direct, infallible means of keeping mankind from destroying himself? But even if there had been nothing else, no other reason at all, UPS still had to come into existence for the very guarantee of the continued life of science itself. What kind of scientist would it be who would take no means to protect himself and the world against the results of his research? Scientists may be many things, Cameron, but they are not irrational."

"I'm not so sure," Cameron repeated stubbornly. "Perhaps your very logic, in the end, will be the destruction of man."

"That's a curious statement," Langley opened his eyes wider.

"To me there is something ominous about this slide rule, cybernetic kind of thinking," Cameron leaned forward and placed his clasped hands on the desk top. "It's thin, too thin; as if equations were being substituted for wisdom. I feel it all about me, a sort of stasis, a frozen mold; as if nothing but technology can develop, and even that frozen into molded patterns of thinking. The capacity of man for unlogic, illogic, may yet be his only solution."

"Oh now, now," Langley leaned back in his chair and shook his head in mild exasperation. "Coming from a man of some intelligence— Look, man," he interrupted himself, "for the first time in history we are governed by reason, instead of superstition and power madness. In these fifty years there has been no war, or threats of war, or persecution of minorities, or graft, or profiteering —"

"I consider the social force which funnels the best of our young men into just such thought patterns, to be a subtle form of persecution," Cameron interrupted quietly.

"Anybody been throwing stones at you lately," Langley asked as if he were talking to a small child in a tan-



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trum. "Or calling your children nasty names?"

"I think neither of us will ever understand the other," Cameron said hopelessly, as if to end the conversation. "You think man has found the solution—the beneficent rule of technology. I think your control system is no superior to any other that man has ever devised, in that it is equally narrow in outlook to all the others. All have come eventually to a dead end. And I see the dead end here, already, in this tension that there is no future except technology and the slide rule is its prophet." Then angrily, "But even that will grind to a halt if you fill our shops with Slaters!"

"What would you have us do with the Slaters of the world?" Langley asked curiously. "Crime, as such, has been virtually eliminated. People are too comfortable to get themselves into such messes. You know as well as I that our police forces have been reduced to a minimum. They don't even need to help old ladies across the street any more. Traffic servomechanisms handle that. There is no need in general society now for the kind of talents, or tensions, you seem to think Slater has."

"Think he has!" Cameron exploded and stood up suddenly. "That nasty, spying, Peeping Tom—"

"But as a shop steward," Langley put the tips of his fingers together and ignored Cameron's outburst, "he is productive. He is using his tensions for the benefit of society. Turn him loose upon his community, without productive direction for the satisfaction of his tensions—No Cameron, you are quite typical of those without the engineering brand of trained thinking. You contradict yourselves so much, and so wildly."

"I take it you refuse to do anything about Slater." Cameron held onto the back of his chair with white knuckles.

"When you get back to the plant, you might send him over. Apparently he hasn't been very clever," Langley conceded, and obviously suppressed a grin.

Cameron glared at him, and then laughed bitterly. His thin, strong face was a study in frustrations.

"I see," he said with finality. "That's all I've gained."

"And Cameron," Langley said placatingly, "don't worry about it. Just go ahead as you always have, smoothing out the little tensions, allowing people to blow off steam to you, arbitrating the little grievances. You're a valuable man, Cameron, with that bedside manner of yours. And you talk the language of the ordinary people who can't, and don't want to learn to think. But let us worry about the production of spaceships. That's really our job, you know. We are the technologists."

He watched Cameron walk angrily through the door. There was a speculative look in Langley's eyes, and he pressed his finger down upon a signal



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button.

In another office a clerk caught the signal, and stopped stalling.

"Why yes, Miss Hills," he said suddenly and flashed her a smile. "I think I can arrange for your inspection party of the new ship. As the plant's dietician, you'll be most interested. It's all fitted and stocked, you know; ready for the take-off. Of course we will seal the control room, that's classified. But the men on this list, with their wives and families are welcome to make an inspection of the rest of the ship. Nice public relations. Tomorrow evening? Will that be all right?"

As she nodded her acceptance and turned away, the clerk pressed a button which signaled Langley's office.

The speculative look in Langley's eye changed to a smile. He breathed a small sigh. Satisfaction? Regret? Could it have been loneliness? Envy? He shrugged his mood away, and prepared to have his talk with Slater.

"Slater! They're coming into the room now!" The whisper brought the shop steward into the room from the hall. It was characteristic of Barnes that though they were seven stories below the room they were spying, he must still whisper hoarsely. Slater came swiftly across the dim basement room to where his assistant crouched over the tape recorder.

Barnes squinted up at him from a round, heavily featured face and grinned triumphantly.

"They're milling around, and there's a lot of incidental crowd noise," he said. "Guess Cameron hasn't come in yet."

"Cameron," Slater exploded, as if it were an expletive.

"Yeah?" Barnes commented with a rising questioning note. "What happened over at Div Tech this afternoon?" He was a huge shapeless blur as he crouched before the recorder, making final adjustments with fat fingers.

"Cameron put the beef on me again," Slater said shortly.

"Bad?" Barnes asked quickly, and turned his head to look up over his shoulder.

Slater grinned down at him, and pulled down the corner of his mouth. His eyes were derisive; his thin face filled with contempt and triumph.

"Yeah," Barnes almost barked the word in relieved admiration, as he interpreted the expression. "Know what you mean, chief. You'd think Cameron'd realize he hasn't got the drag with Div Tech that you have."

"Div Tech knows who's loyal," Slater commented; then added significantly, "Same as I do. You rig up that decoy mike?"

"Sure, chief," Barnes chuckled. "Handled it myself, personally. Put the video eye in back of the light reflector. If they look for it, they'll be looking right into the light and can't see what's behind it. Then I hid in a



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dummy mike which won't be too hard for them to find."

"That's right," Slater complimented.

"That was a smart idea you had, chief." Barnes said with extravagant admiration. "They get rid of the dummy mike and then think they're safe. Smart, chief." A part of his admiration was genuine, a part of it job insurance.

"You got to be smart to hold my job," Slater commented. "Div Tech don't give a stupid man a second chance. Them engineers want just one thing, results. Got the real mike connected to the recorder? I want evidence this time. Real evidence."

"Sure, chief," Barnes answered.

"Turn on the video, so we can see what's going on up there," Slater commanded. He looked about the storage room critically.

"I checked this room, chief, personally," Barnes reassured him hurriedly. "Nobody's got a spyeye on us."

"You're sure of that."

"Sure I'm sure, chief."

Slater walked over and took a chair in front of the video. Barnes and his assistant, who had been hovering unobtrusively in the background while the great men talked, sat down in chairs behind their chief. Theirs was the exaggerated respect and deference to a superior found in men who are arrogant to those they can command, slavish to those who command them.

Technology had gone ahead, but psychology was still blundering around in its blind alleys; not yet ready to give up its fond theories; still preferring to tailor men to fit the theories; still looking through the wrong end of the microscope. Thus there had been no relief for men, such as these, from their warps, pressures, tensions. They still must find their satisfactions as best they could from the frustrations and unrealities psychology still fostered.

"You recording the video, too?" Slater asked.

"Sure, chief," Barnes answered. It was wonderful how he had done everything the chief had thought of. He felt a warm glow of self-approbation. "Installed the recorder right behind the eye in the ceiling, like you said."

"You check the mechanism to make sure nothing will go wrong?" There was a sharpness to the question.

"Why no, chief," Barnes answered in apprehension. Then caught himself. Why hadn't he lied? "I thought you checked it," he alibied hurriedly. "You handed it to me and said install it. I thought . . . I'm not . . . I didn't—"

"All right, all right," Slater shut him off disgustedly. "Sloppy, Barnes. Sloppy! Too late now. I got no time to check every little detail. I got conferences over at Div Tech to attend to. Not one man in a million gets called in to Div Tech, Barnes. You know that. A man who gets called to conferences



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in Div Tech has a right to have assistants he can depend on."

"Yes, chief, you sure have."

"Figure it out, Barnes," Slater went on slowly, remorselessly. "I think I got a man here I can depend on to handle the details. I leave it in your hands. Confident I got me a good assistant. But you don't check it. And you call yourself a Security man!"

Barnes was crushed, abject, then roused to turn on his assistant fiercely.

"You check it?"

The assistant looked up startled. Secretly he had been enjoying Barnes' discomfort, unable to look far enough ahead to realize it would all turn on him.

"Forget it, I said," Slater commanded through thin lips. "Don't pass the buck, Barnes. Too late now, anyway. We'll just have to take our chances that nothing will go wrong. But I don't like it. A good Security man doesn't take chances. None at all."

"I—" Barnes started to rise to his feet, as if to come over to the side of his chief.

"Forget it, I said, and siddown!" Slater shouted at him. Then more quietly, "I said I wanted to check this meeting. There's Cameron now. He's already come in and is going up to the front of the room. You guys yak-yaking made me miss what he's been saying. Security men!" he exploded in added disgust.

The two men sat on the edge of their chairs behind him, hardly breathing, dreading the thought of a future where they might not be permitted to carry on their work; might not enjoy the secret feel of power over other men; the delicious sensation of storing up little remarks, actions, emphases, to bring back to the chief. His praise. Self-sacrificing, noble, loyal men. Somebody has to look out for the welfare of the company, Div Tech.

They sat in abject misery, alternating looks at one another with looks at Slater's back.

Slater, conscious of their apprehension, pointedly doing nothing to relieve it, leaned forward and turned up the volume on the speaker.

"Gentlemen, and Miss Hills," Cameron opened the meeting. He stood, slender and intense, at a small table in the front of the room, and looked over the dozen men and one woman who sat in front of him. "I've called you here this evening for a purpose. I know it is after hours, but during the day it's hard to get you all together. You're all key men in the company, and I've brought you here to ask your co-operation—"

"Hey, Art," a voice called from the back of the room.

Cameron stopped suddenly and looked at the speaker questioningly.

"You don't have to be careful, Art," the man called out. "I found their mike. They were even more careless than ever. Hid it in back of



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that table over there in the corner. I just sort of accidently shifted the table against it, hard, and smashed it. They won't hear anything, and they'll think their mike got smashed by accident."

Cameron grinned at them with relief, and relaxed his official pose.

"Good going," he said. "I couldn't ask, you know." Then he became deadly serious, and this time he took control of the meeting without any make-believe about it.

"Mona tells me she got that list of us approved for a tour of the ship tomorrow night."

There was a stir around the room, a collective sigh of relief, looks of congratulation in the direction of Mona Hills.

"You know what that means," Cameron continued. "Tomorrow night we and our families will enter the ship on an inspection tour. Big privilege for special people!" he exclaimed ironically. "We will close the locks, break the seal on the control room door. We then, instead of Div Tech's picked puppets, will take that ship and head out for our planned destination."

There was complete silence in the room, not even the rustle of cloth.

In the basement room below there was a sharp gasp from Barnes as he heard the incredible conspiracy. He leaned forward as if to see around Slater better. The side of Slater's face was set in a grim mask, and Barnes felt a warmth of anticipation.

"I know you've all briefed your families again and again," Cameron was saying now from the video. "No favorite toys for the children. No treasured wedding presents from Aunt Minnie. Just the clothes you have on, nothing more. There must be nothing to arouse suspicion from Slater's security guards. They'll be suspicious enough, as it is, because we've all brought our children, without giving them anything else to excuse their looking closer.

"It's not going to be easy, leaving everything," one of the men sighed aloud.

"It's never easy to break away from comfort and security, old ties and sentiments," Cameron said firmly. "But it's even more difficult to stay here; to watch this civilization deteriorate into another thousand years of dark ages. With all our fine glittering technology, we're making no more progress than was made a thousand years ago. Technical science can become as stern an inhibitor as superstition."

He broke off suddenly, and grinned wanly.

"Excuse me, folks. I'm riding my hobbyhorse again. We've been all over it before. No one in this room would be here unless we all knew, beyond all doubt, that each agreed the only hope for man was for some of us to break away, get our children away, before they, too, become robotic in their thinking—little animated



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cybernetic machines.

"And there's no other out. I went over to Div Tech this afternoon; on an excuse to complain about Slater, but hoping I could arouse some spark, some doubt that technology is heaven and all's right with the world. Not a chance. They are so fatuous, so smug in their rightness; so closed of mind that not even the slightest doubt penetrates.

"Most of you are technologists; most of you are members of UPS. I don't need to review the long months and years I tested you before I voiced my plan. But I found that you, too, wondered if the fate of man wasn't something more than just to make bigger and better machines.

"We have a good cross section here of the necessary sciences; one of you is an astrogator, another is an experienced test pilot, Mona is our authority on domestic sciences. All of you have been training yourselves in supplementary sciences, and your wives.

"I've visited your homes. I saw no spoiled and whining brats. You've been training your children to sustain in a harsher environment. You've gone against the tenets of psychology whose purpose is apparently to create irresponsible and dependent weaklings. Your children are brave and stoic, perhaps better able to withstand the rigors of a hostile environment than you and I.

"The ship is fitted. It alone will sustain us for two years while we adapt. Gentlemen, and Mona, we have been preparing for a long, long time. We have every chance of succeeding. And we have already proved trustworthy to one another. No one suspects. Tomorrow night, then, we —"

His words were interrupted with a faint clatter of some mechanism, as if a ratchet had slipped its bearing and was whirring against an obstruction. Every eye turned in alarm toward the source of the sound—the light fixture.

Seven stories below, the three Security men saw every face turned directly to the spyeye. Barnes, stricken, buried his face in his hands, as if to shut out the sight, shut out the sound of the whirring, clattering noise picked up by their mike. He rocked back and forth in an agony of apprehension.

"No, no, no," he moaned over and over. "The scanning disk. It must have slipped. How could it have slipped? Chief, they just don't slip! I should have checked it. I should have checked it."

Slater sat and watched the video screen impassively, his lips a thin white line. He saw the men in the room above pull a table over to get at the light fixture in the ceiling. He saw one of them pick up a chair and begin smashing at the light fixture, poking a chair leg at the spyeye. The video screen went dark, the sound shut off suddenly. There was silence in the



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basement room, broken only by Barnes' soft moaning.

"I should have checked it. I should have checked it."

He stumbled to his feet, his eyes wild, his only thought to get out of the room before Slater could turn upon him in slashing wrath; before the terrible words could be said which would sever him from his job. Blindly, he rushed out into the hall and slammed the door shut behind him. Maybe if Slater got time to cool off first; maybe then Slater wouldn't say the fateful words at all.

There should be some way to keep Slater from saying them, some way he could redeem himself. He thought of the men in the meeting room upstairs. What would they do now? They'd been discovered and knew it. He paused in his headlong flight down the hall and stood still. Of course! He could still redeem himself!

"Put a tail on everyone of them," he mumbled aloud. "I got plenty of men. I'm still second in command. Get a man to follow every one of them. Report back to me what they do. I'll hide. Tell the men to bring the reports to me. Slater won't know. Then I'll get all the evidence and turn it over to Slater. He won't fire me then. He'll be proud of me."

He rushed his great bulk to the elevator, urgently pressed against the signal button, giving the emergency signal which would make the operator skip everything and rush with express speed to this basement floor.

In the darkened room above, Cameron's voice came to each of the members of the conspiracy, bitter and bleak.

"That tears it," he said. "Our inspection permit isn't worth the paper it's written on now. As soon as Slater can get anybody to listen to him over at Div Tech, it'll be canceled. And that's the least of our worries."

"Maybe that's our clue," a voice, obviously being controlled with effort, came out of the darkness of the room. "As soon as he can get anybody to listen to him, you said, Art. And who's over at Div Tech this time of night with authority to cancel it?"

"We'll carry out the plan tonight, then," Cameron answered quietly. "Get your families together. Now. Assemble in an hour or less at the recreation hall across from the entrance to the blast field. We'll try to bluff it. Tell the guards the tour was set this late at night to avoid publicity."

"If they notice the wrong date on the permit?" Mona asked.

"Bluff that, too. A clerical error, we'll say. Even Div Tech makes mistakes."

No dissent was voiced. They might still carry out their plans. There was a movement of chairs as the standing people unfroze from their surprise at discovering the spyeye, and moved through the darkness toward the door.



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Light from the hallway streamed in as someone opened the door.

"And gentlemen," Cameron called loudly, "please attempt to be more prompt with your reports, hereafter." He had no hope that the meeting had been unobserved, but with the secrecy which was Slater's nature, he hoped Slater would tell no one before he went to Div Tech. To carry on nonchalantly might still win them through.

"O.K., Mr. Cameron," someone called back to him.

"Him and his infernal reports!" someone else grumbled, as they went down the hall toward the elevators. One never knew what lurking Security officer might be hiding around a corner, or in an office with the door open a crack.

The group walked leisurely down the hall, commenting on the points raised in an imaginary meeting; wondering, as department heads normally do, if Cameron was as smart as he pretended to be; and where he got the authority to call them into a meeting this late in the evening.

As they left the building, and parted outside the Security gate, each was picked up by a Security man assigned to follow him.

Barnes sat slumped at his desk, head pulled down into the hard roll of fat which ringed his neck. His heavy lips jutted out as he turned his hand over on its back, and flipped it palm down, again and again.

"You call yourself a Security man!" He heard the scorn in Slater's voice rasp across his memory, and drew his heavy brows together. The pressure of anger and frustration was too great to allow him to sit still. He flung himself out of the swivel chair and began to pace the floor.

"When will they start reporting?" he questioned aloud. The acoustic board of the walls and ceiling muffled his voice. He looked at the clock set in the wall and realized that only an hour had passed since that crowd of subversives had left the building. He continued to lumber heavily about the room in his nervous pacing.

"You call yourself—" He shook his head bullishly to shake off the echo of Slater's contempt. He felt his heart quicken, the gnawing at his stomach as, in his imagination, he looked at the blue slip of an Unfit Discharge; the obscurity of the Common Labor Pool. Of course, there, he might pick up quite a little information, get reinstated. And then realized that even there the men would avoid him, dummy up when he came around. There is no contempt like that of men against one who has tried to trap and snare them; deliberately made a career of doing it.

In his sharp turn, the holster of his gun pressed against his side. He looked at it and the blued steel of the butt winked back up at him. His hand fell to caress the satin of the metal. With



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a spasm of despair, his hand gripped hard around the butt of the gun, drawing reassurance from its strength. Rather than part with it —

The red glow of the intercom winked at him from the desk. In two strides he was leaning over the desk, not taking time to get around to his chair.

"Barnes here!" he grunted at its speaker.

"Barnes, this is Littlefield!" The voice at the other end was gasping as if the speaker had run a long way, and excitement mixed with terror in the tones. "They're . . . they're going to make the break tonight!"

Barnes remembered that Littlefield had been the assistant in the spyroom with them. He had forgotten the assistant, and his witnessing the scene of his disgrace. Time to take care of Littlefield later.

"They're *what?*" Barnes' hand gripped the edge of the desk until the knuckles stood out in sharp white against the red flesh. "What are you talking about?"

"Barnes, listen!" Littlefield was urgent, frantic. "They slugged me. I was outside Cameron's window listening. I heard him tell his wife. Then something hit me. When I came to, the house was dark, everybody was gone, and I was tied up. I worked loose, and got to an intercom phone so I could call you direct, like you—"

"Hold it!" Barnes shouted back into the intercom. "See any other guards? Check with the main gate?"

"No, I—"

"And you call yourself a Security man!" Barnes roared the words into the speaker grid.

"But you said not to —"

"Shut up!" Barnes commanded. "Get off the line!"

He flipped the switch and glared about the room. Tonight. That meant immediately. No telling how long that fool Littlefield had been knocked out, what had happened since.

"I'll break him," he mumbled to himself. "I'll break him down so low—" He felt it was his duty to break Littlefield, not realizing his satisfaction in it came from revenge for Littlefield's having been a witness to his own disgrace. He flipped the switch on again.

"Slater!" he instructed the speaker grid. The instrument sat silent. Barnes could wait no longer. He pressed the emergency key down and held it.

"No answer," the robot responded.

"There has to be an answer," he said desperately, as if he were talking to a human being.

"No answer," the robot repeated.

"Pattern six," Barnes commanded. "Open line." That was the search pattern, the robot operator ringing all the places in the building where Slater might be. Barnes listened, as one by one people answered the call through the vast area.

"Not here."

"Not here."



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"Not here."

Barnes began pacing the room again, as the reports went on and on. What was he to do? They were going to steal the ship, might be trying it right now, and Slater wasn't to be found. A phrase from the Security Handbook ran through his mind. "Security men must be able to act on their own discretion where formal chain of command breaks in an emergency."

He stopped his pacing. Yes. Not finding Slater could be a bigger advantage. The record of all his attempts to find Slater would be on the tape. He began to hope the intercom could not find Slater. Missing at a time of great emergency. Slater not to be found. He began to pant in his eagerness. It would be checkmate. Slater wouldn't dare fire him then. Don't tell on me and I won't tell on you.

At first, just the cancellation of errors. Then the implications began to grow on Barnes. Not for just now would he be protected, but in the future, too. All the things he'd wanted to do, and hadn't dared. A parade of faces began to flow through his mind: The sullen eyes, the concealed sneer around the lips, the sudden stop of voices when he came upon a group of men. A little roughing up would change that. Change contempt to fear. And he could get away with it now. There'd always be that record hanging over Slater, to prevent him from stopping it.

There was a sudden change in the monotonous negatives coming from the intercom.

"Try Div Tech," somebody said. Barnes felt a flare of frustration. He'd find out who that was. He'd—

But it would be on the tape. He felt his plans come crashing down around him, a physical weight.

"Try Div Tech," he instructed the intercom needlessly. He waited. He listened for the Div Tech robot's answering report. It came.

"Slater is in meeting. No one can be disturbed here."

That, too, would be on the tape. He felt his hopes spring up again. But the record must be complete.

"Emergency," he said dully, fearing the word might get him through.

"Repeat," the mechanism answered. "No one can be disturbed."

The flare of hope, triumph. Now it was all his. He'd tried everything. A checkback of tape records would show, when the investigation came.

Then the enormity of it hit him. In gathering the guards to stop the Cameron crowd something could go wrong. Maybe somebody would get hurt, killed. Did he want that responsibility? What went on over there at Div Tech? When they were questioning him later what instruments would be concealed in his chair or around the room, recording how he felt about things. The lie detector!

No! Slater had to be found! Had to take the rap!

"I'll go to Div Tech in person,"



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he mumbled. It was a resolution of desperation. He had never been in the building. Only Big Shots ever got in. But Slater had to be found, to take the rap.

He rushed out of the office, down the hall to the elevator, fumed impatiently at the inactivity of standing still while it carried him to street level, and then out through the gate to the street. The lights so near to the plant made the street as bright as the daylight, and the pedestrians could see his uniform and gun holster clearly. For this once, he took no pleasure in the sudden set of their mouths and the wary expressions of their eyes.

He ran across the intersection, narrowly avoiding a pedestrian standing on the opposite curb. He ignored the trafficservo and the warning siren whine as he broke the red light's electric beam. He knew a picture of himself had been taken in the act of jaywalking, and he would hear about it, but the emergency—the emergency!

He broke into a sprint, only partly conscious of the stares of the passersby —stupid weaklings who were never faced with momentous emergencies. A time such as this made up for all the accusations of sitting around and doing nothing.

Half a block away, the low outlines of Div Tech arose out of the night. At the corner of the building he slowed to a walk, and approached the inconspicuous door of the building. They were so sure of themselves, they didn't bother to post Security guards, even at the entrance.

His feet were still slower as he approached the three low steps which led into the recess where the steel doors waited. He forced himself to walk up the steps, as if he belonged there, as if this weren't the first time he had ever dared, as if the spasms of awe and indecision were not gnawing at his stomach.

His hand faltered as he reached out to touch the entrance button. He felt the eyes of the scanners on him, knew that his trial was being taped. Would he be censured or praised?

"No admittance!" a mechanical voice instructed him. That was all.

He turned away. Div Tech had refused him.

A surge of unreasoning anger. He wasn't good enough to be admitted to Div Tech. There hadn't even been an inquiry. It might be the most vital thing in the world! It was!

He would show them. He would accomplish the entire thing by himself. Without Slater, or Div Tech, or anybody. And so simply. All he had to do was instruct the guards at the entrance of the launching field not to admit the Cameron party. That was all.

He started to run, heading for the belt which would carry him to the launching field. As he ran he checked the gun in its holster, exulting in the feel of it against his palm, regretting



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that he might not get a chance to use it, that stopping the Cameron party would be a routine thing only. He hoped one of them would argue, start a scuffle, maybe. What was the good of carrying a gun if you couldn't use it when you needed it?

He rushed through an entrance of the guard rail, and leaped upon the belt. It was too slow. It crept at a snail's pace. He started running down it, adding its speed to his own.

"Stand still," the command came mechanically. "It is dangerous to move while on the belt." There would be another picture of him violating a safety code. He ran ahead, receiving repeated warnings as he passed two more check points. Then the belt slowed, and a barrier sprang up in front of him and behind him. He had forgotten that. Forgotten that when one didn't obey them, the mechanisms could retaliate. A siren began to sound.

He vaulted over the guard rail and ran down the sidewalk again. He was almost there. Far up the street he heard a general police car pull around a corner, its siren giving him plenty of time to escape. No matter, he was there now. The huge pilings which framed the entrance gate loomed in front of him, and seated under the light inside the guardhouse, the Security man was on duty. The man heard the distant sirens coming closer, heard the running feet, and came over to the application counter.

"Hey you! Why . . . er . . . Mr. Barnes!" he stammered. "Excuse me Mr. Barnes, I'd never have shouted—"

"Never mind, never mind!" Barnes stormed at him. "Anyone go out to the ship tonight?"

"Yes, sir. Of course, sir. The inspection party, sir—" He broke off as Barnes grabbed him and began shaking him.

"Where are they? Where are they, stupid?"

"Out at the ship, sir. They were official, sir."

"How long ago?"

"Perhaps fifteen, twenty minutes. Wait a minute, I'll check the tape."

"Never mind, you fool! And I suppose you gave them station wagons."

"Well, sir, I didn't give them cars, no sir. I sent along drivers. They were official, sir. Had an authorization signed by—"

"I know, I know. Oh you stupid fool!"

"But it'll be all right, sir. In fact, sir, here they come back now."

Barnes squinted down the long road leading out to the distant gleam of the ship. He could barely make it out past the two returning cars, bathed in their own floodlights.

"It's not possible," he muttered to himself. "And they wouldn't be coming back so soon from an inspection party anyway."

"Something's wrong," he shouted. "Signal them to hurry."

The two cars gave a sudden lurch



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of speed and pulled up to the gate within another minute. Before they had stopped, it was apparent they were empty, except for their drivers.

"Get this gate open!" Barnes shouted. "I'm going out to the ship."

"Look!" the gateman shouted as loudly and pointed.

There was a flare of light around the huge ship. Slowly, ponderously, seeming to rest on its mushroom of flame for an eternity, the ship arose, inched upward, and then began to streak, faster and faster.

"Well, gentlemen, there they go." The quiet voice of Langley cut across the silence in the room, the understating quality of it somehow relieving the drama, reducing it to routine. "They made it. On schedule."

The eyes of the other men still followed the bright streak of the ship, the fading afterglow of incandescent air molecules. After a while, that, too, was gone. Only the stars blinked clear and cold, sharp in the desert air, bright through the huge quartz window of the upper floor of Div Tech.

The chief administrator of World Tech Control, visiting the Pacific Coast for this occasion, dropped the heavy curtain with a sigh—longing? —envy?—doubt?—and walked back to his chair in the corner of the room. Someone turned on the lights again, and the dozen men, assembled, looked at one another, self-consciously washing the dream from their expressions.

It was Slater who voiced the doubts, a Slater whose face would hardly be recognized by his Security Men, a Slater of quiet, profound wisdom, of deep compassion. He expressed the inevitable doubts which arose each time a ship of colonists went out into the void.

"I don't know," he said. "I don't know if they were the right ones. I'd begun to doubt they'd go through with it. Seemed to me it took an extra amount of needling, irritating, annoying, pressuring them into doing it. I had to encourage some pretty nasty tensions in my men, and then at the last frustrate them."

He thought of Barnes, knowing his patterns intimately, feeling as if they were his own, Barnes' desperation when the old-fashioned disk scanner had slipped and revealed itself, slipped as he had planned it would when he carefully rigged it. He knew, also, the subsequent moves of Barnes, as certainly as if he had observed them —the uncertainty, the scheming, the frustration, the purposeless activity, all of which would prevent Barnes from ever coming to a decision until it was too late for him to interfere. Slater shook his head sadly.

"I had to set up the events of tonight," he said, "in order to give them that last minute desperation. Very nearly destroyed my man by doing it. I was afraid that if I didn't push them into it, they'd back out at the last minute. I don't know if they were the right ones. Even as late as this after-



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noon, they were still undecided. That's why Cameron came over to see you, Langley. He still hoped they wouldn't have to go. It was nip and tuck. If you'd said the wrong thing—"

"Yes," Langley said, "but it's always nip and tuck. Put too much pressure on a man and you break him. Put not enough pressure on, and he adapts to it, makes the best of it, willing to pay that price to be let alone. In that sense, Cameron's crowd was no different from the others. Just the right pressure to shake a man out of his inertia, and yet not break him, requires some pretty careful calculation at times."

"But we're still agreed," the chief administrator said with a questioning note, "that we are following the right program. Aren't we, gentlemen?"

At their slow and considered nods of agreement, he reviewed their program briefly.

"We recognized a long time ago that no one development of a civilization will find the solution. In all the past, each civilization of history has developed something, but never more than two or three things of significance. They pursued this particular path they chose until they became too specialized in it, then they died. Cameron was right, you know. Technology is not the solution, either. Not the whole solution."

"But Cameron did overlook this," Langley said, "that we are smart enough to realize we haven't got the solution."

"He'd never have got his crowd together and escaped, if he'd recognized that," Slater commented. "He'd have waited, hoping the solution would be found some quick and easy way."

"But suppose Cameron's colony does survive and develop its own trend to a logical conclusion," one of the men seated along the wall commented, "what will he contribute? It seemed to me he was too well balanced, too well adjusted. That his whole crowd was. You know, as well as I, that the great contributions to mankind, the great surges of history have come from the aberrated, the fanatic, not the rational."

"Yes," another individual agreed. "The reasoning and well-balanced individual plays his part later, after the blood and dust have settled. It is then that he rationalizes this aberration into an advancement for mankind, and integrates it into the lives of men generally. I don't think Cameron was fanatic enough to contribute—"

"That's the point, gentlemen," the chief administrator said. "We can't know where the final solution may come from.

"But consider this: We have said these aberrated surges have constituted human progress. Maybe they haven't. Maybe they have kept man perpetually on the verge of self-destruction. We can't know. If we knew,



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then we could postulate the solution here and now.

"We know this, or think we do: That the law of life is that the strong shall survive. In order to survive the vicissitudes of another planet or the larger satellites, the bad atmosphere, gravity conditions, who knows what forms of hostile life, a group has to be strong, daring, determined; as purposeful as the Pilgrim Fathers, and as desperately driven. Strong enough to escape Tech Control, gentlemen; to conspire against and believe they have outwitted Earth.

"Civilizations on Earth developed independently, and therefore followed divergent paths, as long as there was no community of the intersocial. But Earth has become all one community, and all concerned with technology to the virtual exclusion of anything else. If we openly and officially populated the planets, and later the stars, then those offshoots would carry the Earth trend along with them, communicating freely back and forth.

"It has to be done the way we are doing it. Colonies of people whose disagreement with us makes them want to try something else. And the only way to keep them there, once they have made the break, is to make them afraid to return to Earth—afraid to run back to Mama when the going gets tough.

"Some of them may be balanced and sensible children, such as the Cameron colony; some are no doubt criminals; some of them . . . I can't seem to get Ship No. 4 out of my mind, gentlemen. Stolen by that zany crowd of hopped up, hotrod szepcats. Just kids. What kind of a civilization will they produce?"

He sighed, and the men around the room slumped down in their chairs. Theirs was the burden of waiting.

Langley put it into words.

"This is only the seventh group," he said. "We must not be impatient. Perhaps the solution won't come until it is our grandchildren, or theirs, who are sitting where we now do. Perhaps not until the seven hundredth, or the seven thousandth—"

"And that may still be too few," the chief administrator agreed. "Many of the colonies won't make it. A few years vegetating while their ship sustains them, and then too weak or too indolent to adapt. Others destroy themselves as we have done by internal conflicts. And this has occurred to us all: We might seed all the universe, and still never find the answer to that simple little perplexity—how can men live together?"

Langley looked at Slater. Slater arose to his feet.

"We may fail," he answered, "but not because we didn't try. Shall we begin, gentlemen, to decide which little seedling we will next mature and permit to escape us out to the stars?"

THE END



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# SURVIVAL

## BY DON GREEN

*There have been tales of the survival struggles of spacewrecked heroes. But here was no hero — just a passenger, a salesman, with no special knowledge, no steel thews — and not too much hope, for that matter . . .*

Illustrated by Dreany

It was a feeling of suffocation that first assailed his returning consciousness. Then cold—biting cold that nipped at the roof of his mouth with each struggling gasp. He fought against the cold and suffocation and returning consciousness with the unorganized desperation of a late sleeper, murmured incoherent profanity and tried to bury his head in the pillow—

He sat bolt upright, wide awake, the kaleidoscopic jumble of sensation-fragments suddenly falling into place, and sickness overcame him as he identified a crushed and broken horror beside him as the "pillow" of his dreams.

Choking from his sickness and from the perilously thin air, he unfastened his safety harness and crawled over the sodden mass that had been his seat companion. Dazedly, he made his way forward through and over the wreckage to the pilots' compartment. The torn door hung half open, dangling from a single hinge, and a glance inside brought new spasms to his tortured stomach.

He turned back to Passengers Section. There had been twenty-two others beside himself, he remembered. One empty seat—the stewardess had commented wryly on what that empty seat was costing the company—the she might— He started aft toward her little closet—and stumbled over her legs.

He recognized her immediately by the once-neat gray uniform she wore. She had been thrown across the bodies of a woman and a child. Probably, he speculated, making her last action an effort to protect the child.

He sighed, and the biting cold stung him again. Reason was flowing back into him now, surging up and over the horror and sickness and shock. Spacesuits—what had the stewardess said? Under . . . under something . . . the seats? Yes, that was it. Under the seats. Like one-piece coveralls, she'd



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said. Step into one, zip up the front, put on the hood and the oxygen mask, and there you were. Not really spacesuits, though, the girl had said. "Survival suits," she'd called them—like life preservers on ocean ships.

But first, before that—the survival suit could wait a few minutes—what about the others?

He picked his way through the wreckage, avoiding the smashed bodies which could not possibly have retained life—and should not if they could—and examined one after another of those who seemed whole.

When the grisly exploration was over, and he knew himself to be utterly alone, he found a survival suit under a seat and put it on. With cold-stiffened fingers he adjusted the hood and facepiece, found the oxygen valve, and drew in a lungful of the life-giving gas.

He sat down in the empty twenty-fourth seat, next to an elderly man whose glassy eyes stared sightlessly at the carnage. He would rest now, try to get warm, and plan what to do.

First, where was he? An asteroid, most likely. But that didn't make sense. Even a landlubber such as he knew that asteroids were supposed to lie between Mars and Jupiter, and the flight had been cutting almost across the orbit of Venus trying to catch the fast-receding Mars. And the gravity—just like Earth gravity. Unless, of course, the clipper's gravity system had survived the crash. Well, those things could wait a bit.

Second, how long would the survival suit's oxygen supply last? He twisted until he could see the canister on his suit, and was horrified to find it half exhausted! He quickly turned the shut-off lever, intending to save the rest for a greater emergency, and the lever dropped off in his hand. In panic he unsnapped the canister from its attachment and held it to his ear. There was now an unmistakable hissing sound as precious oxygen leaked out of its container, but puzzlement gave way to relief when he saw the pressure indicator change hardly at all. It must have been leaking all along, he said to himself. Probably damaged in the crash. He found another suit whose canister registered "full," and exchanged that oxygen mask for his own.

The suit had now warmed him, the pure oxygen had made him a bit giddy, and he began to feel what he presumed to be the after-effects of shock, so he turned the oxygen valve down to a bare trickle and made himself as comfortable as possible in the seat. He slept.

The next time he awakened it was from a nightmare in which he was being roasted over a slow fire. His eyes opened to burning sunlight streaming through jagged rents in the wrecked clipper's skin. He pulled off his mask, then hurriedly replaced it when he found the air to be even more rarified than before. Then, too, the heat was



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beginning to do unpleasant things to the bodies of his fellow passengers. He was glad of the mask, even without its oxygen supply.

He began to shed his survival suit, which was uncomfortably warm now that the sun was shining, but quickly zipped it up again when he discovered that the suit was as effective an insulator against heat as against cold. The temperature outside his suit was unbearable!

But what about the sunlight? He tried to remember back to his first awakening after the crash. Had it been dark outside? Certainly it had



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been cold, but he couldn't remember about the sunlight. It didn't seem to have been quite as bright as now, though he'd been able to see clearly. He glanced around, trying not to look at the human wreckage intermixed with mechanical wreckage, and saw then some of the interior lights were still burning.

That made two things. The lights were still burning, and so there was a power supply somewhere. And that, of course, meant that other equipment and facilities of the clipper might still be in working order—the gravity system, for instance. In any case, there was a power supply available to him—if he could find it, if he could figure out how to use it, and if he could think of anything to use it for.

And it meant something else. If the gravity system *was* still functioning, then the gravity of this planet, moon, asteroid or shooting star on which he'd crashed might be impossibly greater or less than Earth's.

Well, no time like the present to find out.

He got up. There was a torn hole just above him, but a little too high. He tried the door through which he'd originally entered. Jammed. Along the side of the clipper, just opposite his assigned seat, there was an emergency door—or "hatch," he believed it was called. He tried it with no greater success.

He thought for a moment. Probably there was an exit in the pilots' compartment. Certainly should be. The pilot, being in command of the ship, must have a way in and out without having to pass through Passengers Section.

He pulled the torn door open and peered inside, then changed his mind. Not that. Not yet, anyway. The pilots' compartment had received the main force of the impact, evidently, and the mess inside was more than he could stand just then.

He went back and surveyed the rips in the clipper's skin.

At last he found one wide enough and low enough to permit easy passage. Pushing aside one of his erstwhile companions, he stood on the seat and looked out.

The glare was almost blinding, and the reflected heat penetrated his hood and mask. Through rippling heat waves, which terribly distorted the landscape, he could make out rocky prominences and crags rising from a flat desertlike wasteland. He could see only a short distance through the glare and the rippling, but a glance downward showed him to be perhaps ten to fifteen meters from the ground. A little too far to jump if the gravity here were the same as Earth's or greater, he computed—and how would he get back, in any case?

He returned to his seat. The heat was intense, and he was sweating profusely. But as he sat down he noticed that the glare which had awakened him now slanted across the



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ruined compartment. Automatically he extended his wrist to see the time, and saw only an arm encased in the sleeve of his survival suit. He examined the wrist of his dead seat-companion. Clumsily, with gloved fingers, he removed the man's watch, wound it, and attached it to the harness of his oxygen canister. This reminded him again of the air supply problem, and a glance at the indicator showed about one fifth of the contents consumed in the half hour or so he had been busy—plus, of course, the trickle he had used during a sleep which might have lasted minutes, hours, or days.

The shaft of sunlight was now moving visibly. As he watched, it crept up the side of the clipper's wrecked interior. Centimeter by centimeter it crawled, and growing darkness revealed more of the clipper's lights still brightly shining. He timed the sunlight's movement, trying to recall some geometrical formula which might translate this movement into axial rotation speed of the body on which he had crashed, but gave it up as a bad job. If he wanted to know, he told himself, he'd have to do it the hard way—time it for a full rotation.

He got up out of the seat. The sun was still above the horizon, but already the oppressive heat was diminishing. He unzipped his suit, and was gratified to find it less warm outside than in. However, in memory of the previous "night" and the fantastic temperatures on this strange world, he left the garment on.

The next problem was made acute by a growling in his stomach. The old human alarm clock was still working, and he realized with some exultation that periodic hunger provided him with a device for measuring time even though mechanical chronometers failed to function. He had eaten shortly before the crash—an hour or so, as well as he could remember, not remembering the crash itself—and so now it must be no less than six hours nor more than twelve since his last meal. Probably eight hours, unless—but no, a man's stomach knows what time it is.

He settled on eight hours as a probable figure, and considered that in those eight hours this planetoid's axis had turned from night to day and was approaching night again. He wasn't sure what good such information would do him, but it was nice to know at any rate. Then he set about the business of feeding himself.

He made his way through the shambles to the stewardess' domain. Here, for once, he was grateful for the nature and direction of the crash. Inertia had piled things forward and fairly well cleared this section of debris and dead passengers. By now he had grown somewhat used to his gruesome companions, but did not relish the prospect of their company at dinner. He discovered that a suitable power supply was in fact



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available, and that the frozen food locker had survived the incredible heat as well as the crash.

How long it would remain so, how long the power would last, he had not the slightest idea. He pondered this as he heated the food and ate, and near the end of his meal he felt the chill of night once more creeping into the ship.

This was more like it. Between the two extremes of temperature he had always preferred cold to heat. And now that his stomach was filled, now that the initial shock had worn off and he had a general idea of his circumstances, and now that the heat had gone away, it was time to do something about the situation.

He considered the matter carefully. In such matters as food, water, and other things of a life-sustaining nature, he could probably satisfy his needs from the stewardess' supplies. But tools, emergency equipment, weapons if they were needed? Only one place, logically—the pilots' compartment. Even in the old days of sailing ships on Earth, the captain took the precaution of storing such gear under lock and key in his own quarters, and this custom might very probably have been carried forward through utility as well as tradition.

He made his way forward once more, propped open the pilots' compartment door, and with gritted teeth began the task of removing the mangled bodies. Pilot, co-pilot, astrogator, communications. Four bodies—or at least enough to make four bodies, more or less. And by now the deadly cold had crept in and begun to congeal the horrid mess created by the day's heat.

He cleaned up as best he could, and began to examine the compartment. He found weapons almost immediately—or some of them, at least. In a rack on the wall, ready for emergency use, were six Thorsen air-guns and two Simms blasters. The Thorsens he understood somewhat, having been introduced to them during his mandatory military training period, and he knew what havoc they could create. But the blasters had been shown only in demonstration, and he remembered little except that they launched an energy blast and were sometimes quite dangerous to the inexperienced user.

Lockers and cabinets in the compartment were still securely fastened, despite the crash. He momentarily considered using a Thorsen gun to blast the locks, but put the idea aside as a last alternative. The Thorsen projectiles were explosive. Instead, he went through the torn clothing of the now freezing crewmen and at last produced a ring of keys together with various odds and ends which he tossed into a little pile for possible future use.

None of the keys fit the locks, and he was forced to repeat the grisly search. This time he collected everything he could find among the smashed



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bodies, added the unimportant items to the growing pile, and tried keys one after another.

In a little while he had opened all the cabinets and lockers. In one he found more weapons—a rack of Gado pistols, similar to the Thorsens but smaller and with less range, boxes of ammunition for the Thorsens and Gados, and even a Kramer heavy blaster that he presumed to be an emergency ship-to-ship weapon. In several lockers were spacesuits—the real thing, not survival suits—but not a single head globe had survived the crash. Other cabinets yielded administrative supplies, stationery, charts, reference books, et cetera; another turned up what appeared to be surveying or mapping equipment; and one, the last one, of course, contained a rope ladder, grapnels, reels of cord, and other climbing devices.

There was a direct exit from the pilots' compartment, and in a few minutes he had it open and was peering down at the dark ground some fifteen meters below. There were attachments for the rope ladder just inside the pilots' outer door, and he fastened the ladder and let the other end drop. It hit with an audible thud.

He took one of the Gado pistols and shoved it into the harness that held his oxygen canister, slung a Thorsen around his neck, and started down the ladder.

Fifteen meters, he'd estimated. There would be four rungs to a meter, he seemed to remember from his military training. Or was it three? No, thirty-three and a third centimeters would make an awfully high step—and twenty-five would be just about right. There was reason behind basic measurements and spacings, he told himself. A standard four-rung-to-meter ladder would be sensible, even as a help in measuring distances such as now.

He let himself out through the opening, found a rung, and placed both feet on it as he slid his shoulders out into the open. Fifteen meters—four rungs per meter—sixty rungs to the bottom if he had calculated correctly. How many so far? He counted downward with his hand and then upward with one foot and knee—seven and a fraction to the opening.

He started down. Eight, nine, ten— The lighted port was above him now, illuminating him in a shaft of light that blinded him against the outside. Twelve, thirteen— What if there was no end? What if he reached bottom and found nothing but an eternal emptiness in which to dangle? But no, there had been the sound of the ladder striking ground. Twenty-four, twenty-five, twenty-six— And then his stomach remained in place as his feet continued downward.

The two things registered at once. His stomach wanted to stay up above the twenty-third or twenty-second step, and his feet felt as though they were thrusting into a pile of feathers.



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Perplexed, he looked downward. Below, seven or eight meters, starkly lighted by the open door above, lay the ground. It was bare, empty, and yet to thrust downward toward it was to encounter resistance—and then he knew.

Gravity! The clipper's gravity system was working, and must be extending an aura to some six or seven meters or so beyond its shell. And after that—

The feeling of resistance to his feet was not resistance at all, but rather a diminishment of weight. And how obvious it was! He had read the stories of space-travelers leaping about under lesser gravitation, but nowhere did he recall anyone recounting the necessity of expending extra energy to compensate for weightlessness on downward thrusts.

His stomach by now somewhat acclimated to its new circumstances, he pushed his feet down one after another. Thirty-eight, -nine, forty— It was tiring work, climbing downward under a different gravitational attraction. Fifty-one, -two, -three, oop! Bottom!

The ground felt sandy under his feet. At least it was dry, moved as he scuffed his toe, and piled up in a little dune. He reached down, picked up a handful, let it trickle through his gloved fingers. Sand it was, but fine sand ground almost to powder by perhaps millions of years of sifting, blowing, and erosion.

He looked around. Beyond the square of light cast by the door above there was only blackness.

He swore. Here he was with a Thorsen gun and a Gado pistol, armed against a myriad imagined horrors which had not materialized, and he had forgotten a light with which to see his enemy or illuminate his exploring. He sighed, and the responsive inhalation sucked the mask against his face—his oxygen supply was gone!

The panic was brief. Perhaps it was the cold, perhaps the emergency, perhaps the simple fact of utter loneliness, but he recovered quickly and remembered the night before when he had gotten by for a long time—maybe for hours—without supplementary oxygen. He took off the mask.

It was thin and brittle air, but air it was. Eventually, perhaps, he could accustom himself to it—for short periods, at least. But now was no time for speculation. He grasped the ladder and began to climb upward.

Fifty-three rungs, he thought to himself. Thirteen-and-a-fraction meters. This was the fifth rung, the sixth —He looked up, and the opening seemed impossibly far above him now. His lungs strained to draw life from the tenuous atmosphere, and his heart pounded under the exertion. Seven rungs— Eight— But wait a moment! What about the lessened gravity? Maybe it could be of use to him. He remembered the stories and pictures



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of men jumping with ease on Mars, which had a gravity about half that of Earth, and literally gliding from place to place on Earth's Moon where the gravity was a fifth or so of normal. What was the gravity here?

He tried to test his own weight, but the swaying ladder and the cumbersome survival suit conspired against him. Hanging onto the ladder with the crook of one arm, he unslung the Thorsen gun and hefted it, remembering that on Earth it had weighed eleven point six kilograms. Here, nearly as he could tell, it seemed to weigh somewhere between one and two kilos. He computed hurriedly—two into eleven gave five and a half, round it off to six. Then gravity here must be no greater than one-sixth of Earth's, and no less than about one-tenth—

There was a ringing in his ears now, no doubt caused by the pounding of his heart and the straining of his lungs. Just another minute, and he'd have it. How far could he jump, straight up, on Earth? A meter, perhaps? Maybe a little more, maybe a little less—call it a meter. Here that would translate into perhaps six meters, possibly ten, and two or three jumps could do it.

But on the flexible ladder he could get no purchase for an upward leap. He mentally crossed his fingers and dropped to the ground, landing gently. He unslung his Thorsen and the oxygen canister, and tossed aside the Gado pistol so as to gain the advantage of less weight. He squatted slightly, grasped the ladder at arm's length above him, tensed, and then hurled himself upward with all his strength.

He caught the ladder as instinct told him he had reached the peak of his leap, and found himself within centimeters of the open door. He remembered quickly that he had forgotten to account for his own height of one hundred seventy-nine centimeters, and had gained additional distance by stretching his arms upward.

Gravity was normal again, now, and the remaining few rungs were climbed with difficulty. But the air was a little richer. A result of the gravity system, he guessed, attracting atmosphere, maybe, or compressing it a little. Something like that. He pulled himself into the pilots' compartment, climbed back into Passengers Section, found another oxygen canister. Then he sat down, exhausted, and breathed deeply of the life-giving oxygen.

He looked at his borrowed watch. He'd set it at 1800 hours—an arbitrary figure which somehow seemed appropriate in view of the sun setting at that time. Now it was 2217, an elapsed time of four hours—rounding off the seventeen minutes in favor of the time he'd spent without oxygen—since he'd tapped that previous canister. Not good.

He cut down the valve to a flow he considered absolutely minimum, and contemplated his circumstances in the matter of air supply. There would



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be at least twenty-four survival suits with canisters attached. He'd consumed two, including the defective container. That left twenty-two, or some eighty-eight hours if all remaining canisters proved undamaged—not a likely prospect.

But there would presumably be a store of extra canisters, and undoubtedly more for use with the now-ruined spacesuits. And the clipper's own air system—maybe something could be done about that.

He wished fervently that his education and experience had included a little more practical instruction in the science of space travel. Undoubtedly there was available to him at this very moment a multitude of tools, equipment and techniques which could make life more comfortable—or at least more certain—and which might put him in communication with rescuers.

But, except for his casual past observations and his present labored deductions, he was helpless. Space flight? Astrogation? He laughed bitterly. Why, here he was presumably hung up on an asteroid where no asteroids should be—that's how much he knew about astrogation. Radar? Directional carrier beams? Electronics in general? He could do a reasonably good job at placing a call on his visiphone at home, and complimented himself that he could tune in a picture at least as clearly as could the fellow next door, but that was about all. If it had been a matter of *selling* a space clipper like this one, well, that was something he could handle. But to run it? To mend any of its broken parts? To understand, even, which parts were actually broken and which parts just looked that way—he shrugged. Nothing.

He heated another of the precooked meals, but encountered more difficulty in consuming this one. Last time, the temperature in the clipper had been rather comfortably balanced between day and night; now it was well below freezing.

He reviewed his activities in the past thirteen or so hours. He'd run through two canisters of oxygen and was on his third, he'd eaten twice, he'd done a little not-too-productive exploring of the clipper, and had been down to the ground and back. Not much progress for a man in life-or-death circumstances, he told himself. Of course he'd been unconscious or asleep for several hours of that time, but still—

He went forward to the pilots' compartment again, and searched until he found a hand-light that was in working order. He hung a spare oxygen canister on his harness, gathered up two more weapons just in case some fanciful monster had made off with those he'd left below, and let himself out through the opening. This time he simply dropped, alighting from the thirteen-meter fall with no more jar than if he'd jumped from a



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small stepladder at home.

He stepped out of the square of light cast by the opening above, and for the first time studied his surroundings.

Beyond a circle of nearby rocks and crags which dully reflected the light from the clipper, all was utter blackness to the horizon.

It was a rough and jagged horizon, outlined against a sky so full of stars as to be appreciably luminous—enough to see by, a little distance anyway, he found as his eyes grew accustomed to the darkness. The luminosity was greater at the horizon, and he speculated that sunlight from the other side might have something to do with that.

There was something else about the horizon, too. Something he couldn't quite understand, except that it was uncomfortably different.

With a hesitant, half-fearful backward glance he started off slowly toward the horizon. This exploration was foolish, he told himself. There might be people—beings of some sort—hostile things lying in wait for him. There might be animals, or horrid and vicious creatures—there had been deadly, semi-intelligent plant life on Venus, he remembered. And colonists had also fought a long and bloody

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battle to gain supremacy over the dune-monsters who from time to time descended in starving packs upon the re-occupied cities of Mars.

But he couldn't spend the rest of his life—long or short as it might be—cooped up in the wrecked clipper. After all, there might—just might—be a colony or station or observation post here on this very world, whatever and wherever this world might be.

He walked on, frequently looking backward over his shoulder as much to see that the clipper's lights still shone as to reassure himself that he was not being stalked by some nightmarish being. And then suddenly he saw what it was that had bothered him about the horizon.

In the first place, the jagged rocks had been *too* clear, *too* sharp. They were not rounded and smoothed by distance from the eye. It was as though they were really very close, though they were actually at the horizon's edge. It gave him the odd feeling of being in a sort of bowl, and yet the horizon did not seem to be *above* the eye level as did Earth's horizon. And then, too, the horizon did not recede as did Earth's when one walked toward it. It seemed to stand steady, co-operative, so that he could approach it, and new crags began to rise up behind.

At about two hundred fifty meters he halted to examine the ground more closely. He played his handlight over the rocks, found them larger and more plentiful here than near the clipper. Ahead they were even more closely packed, forming a sort of ridge which seemed to taper off to right and left.

He picked his way onward among the rocks and over rising ground, climbing at last to the top of the ridge which rose only thirty or forty meters above the ground level from which he'd started. Beyond was flat land again, dotted with the same rocky formations, and another ridge farther on.

To the left another wasteland stretched away, and also to the right. He turned, with a feeling of having accomplished nothing important, and started back toward the clipper.

Perhaps, he thought to himself, he could come back here in daylight and build some sort of signal. He could try one of the spacesuits. Even with a broken globe it would keep out the heat better than a survival suit. He could figure out how the Simms blasters worked, maybe build or carve out of the rocks a giant request for help—something that would stand out, not be misunderstood . . . but that was absurd! What better signal than the wrecked clipper itself?

He trudged on, flashing his handlight ahead and to the sides. Among the rocks, he noticed casually, were occasional fissures and crevices. Some were but insignificant cracks, others gave the appearance of yawning



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caves or tunnels.

He continued on toward the clipper, then on an impulse stopped and swung his light back to one of the larger openings. It was indeed a sort of cave, and he went over to it.

Roughened by erosion from its mouth to some distance back, thereafter the cave's black walls showed themselves to be smooth and dully polished. Volcanic origin, he thought to himself, and hoped that this celestial body was not given to internal disturbances. At a distance of about fifteen meters, the cave angled off to the left. He walked to the turn-off and played his light into the next section. It, like the first, also angled off after about twenty meters—and this time to the right.

Curiosity aroused now, he once again followed the corridor and peered around the corner. He was disappointed. In some ten meters, the cave narrowed down to a diameter too small for him to follow and gave every indication of ending shortly beyond.

He emerged from the cave, and stood for a moment looking at the sky. In all the vast uncountable multitude of stars, he recognized nothing familiar. No Moon, no Big Dipper, no Orion's Belt, not even the brightly shining Venus or the ruddy glow of Mars. Even the vast sweep of the Milky Way was obscured by a horizon-to-horizon canopy of sparkling lights. How in the world did astrogators find their way about, with reference points swallowed up this way among the billions of stars not visible through Earth's atmosphere?

He felt a little better, a little less stupid now, as he walked back to the clipper.

In the pilots' compartment he sat down at what was left of a control panel. For all the good it could do, or the information it could furnish him, the panel might as well be smashed completely. He could make nothing of the remaining instruments, and could only vaguely imagine the meanings of labels and instructions on the board. More important to him now was how to survive—maybe for weeks or even months—until help came. It would come, it must come, he told himself. But it might be quite a while.

First, he decided, would be housecleaning. The bodies of his fellow passengers would have to go. Maybe he could arrange a burial of some sort later, but in the meantime they must be gotten out of sight for reasons of sanity as well as health. With a gloved finger he gingerly touched one of the four crewmen stacked outside the pilots' compartment. Frozen solid. And frozen to his companions, too, in one icy blob of mangled flesh and clothing.

He knew without looking that the passengers would be the same—frozen in their seats, frozen in their contortions, the messy ones probably frozen



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to the wreckage. Nothing to do but wait until daylight, then they'd thaw and he could untangle them. He sat down and waited.

Again he speculated on his circumstances. There was food enough for weeks, if the power stayed on. And, what with the reserve supplies he'd not yet found but which must be on board, there would be oxygen for a long time. He thought about the atmosphere outside. It was thinner by day than by night, he'd found. Maybe it was a relatively thin blanket of air which expanded under the sun's heat and contracted in the cold? Did air do that? He shrugged. *Something* made it thinner in the daytime.

He reasoned further. If alternate heat and cold were causing expansion and contraction, then perhaps in one of those caves he might find a more even temperature and thus a more regular atmospheric density—and maybe a little more density, as well. That could be a partial solution to his problem. He could find a cave that angled back and forth—like the one he'd explored—so as to baffle direct sunlight, and set up housekeeping there! It would be warmer by night, he felt sure, and cooler by day, and possibly at times he could do without the cumbersome survival suit. And at night he could build a fire—

He felt pleased with himself. No wonder humans had risen so far above the animals. Why, with the gifts of reasoning power and logic, they were all-but indestructible. He'd be here waiting, well-fed and comfortable, whenever the rescuers chose to pick him up.

In the meantime, though, the corpses would have to go. They'd have to go eventually, anyway, for he contemplated virtually dismantling the clipper in the equipping and furnishing of his cave-house.

Dawn came at 0230. He felt quite pleased at this, partly because his earlier time-calculations had been proven substantially correct, and partly because he now had a definite standard of time measurement by which he could plan his actions.

He set to work immediately. He estimated some two hours or so would be available before the temperature became insufferable. After that he might try the spacesuit idea, but he wanted to have things well under way in case the plan proved unworkable.

Some few of the slightly damaged bodies were movable—awkward, but movable. One by one he tugged and pried them out of their seats and into the aisle. They lay there stiffly, their frozen limbs twisted and rigid in the grip of sudden death.

It was hard work, and for a moment he considered the idea of finding and turning off the gravity system to make things easier. Then he dismissed it as a dangerous idea—better to leave such things alone for the time being.



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By the time he had filled the aisle with corpses, they had begun to thaw. Gradually the accusingly outstretched arms and legs lowered, the arched bodies slumped, and the head rolled lifelessly to one side. He dragged them forward, then, and pushed them one by one out the pilots' door.

The aisle cleared, he returned to his task and began disentangling human ruin from the shattered cabin. Despite the growing familiarity with his work, and its urgency, he became sick twice before the job was done and he stood alone in a reeking, steaming charnel house.

His watch now showed 0412, and he realized that he was hungry as well as hot and tired. He rested for a few minutes, then fixed himself another meal.

This done, and the waste from this meal as well as from the other two gathered up and thrown overside, he went forward to investigate the spacesuit matter.

There were six suits hanging in the locker. Every one, as he had noted previously, had its head globe shattered. But with a little cement, he thought, perhaps he could piece one of them back together after a fashion —not air-tight, of course, but that wouldn't be absolutely necessary. The oxygen mask from a survival suit would do for air supply.

Somewhere, he had read or heard that these spacesuits had an air-circulatory system of some sort. It seemed to him that a reasonably intact head globe was probably essential to such circulation.

He mulled over the idea of circulated air as he inspected the suits, looking for the one with the least damaged globe. Why did the air circulate? He recalled something about a heating device—maybe it heated the air and the warm air was then forced throughout the suit? Something like that, but not quite. There was something else—

He selected his suit and carried it to the control panel which he would use as a sort of work bench. He found the clamps that held the broken globe in place, four of them, and removed the plastic bowl from its ring. Then he returned to the locker and scooped up a handful of transparent fragments.

Perspiration ran into his eyes as he bent over to pick up the pieces, and he cursed. This was going to be a job if he had to contend with the heat as well as the meticulous detail of fitting globe-pieces together—and he knew that the temperature would continue to increase for another two hours or so. And then suddenly he remembered *why* the air circulated in the spacesuits.

The sun was hot out in space. Hotter by far than it was here, and that was almost unbearable even in an insulated survival suit. But the vacuum of space had no temperature



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and could hold none, and so the air in a spacesuit circulated— carrying hot air from one side, where it had been heated by the fierce rays of the sun, to the other side where it swiftly radiated into the empty nothingness outside.

But in some circumstances, such as when a man was shielded from the direct sunlight, he was surrounded by awful cold. Then a heating device would cut in and circulate warm air through the suit. And conversely, there would be a cooling device for use in opposite situations—like now, for instance.

He put the handful of fragments aside, and eagerly sought for a way to get into the suit. Fastenings at the shoulders opened up, he found, and one stepped into the garment as into a large sack.

He got his feet into the suit, and pulled it up to his waist. Better examine a little more before getting all the way into it, he warned himself. There was a switch-panel of sorts mounted on the suit's front, about the chest, and he twisted the garment around so he could see the controls. Temperature adjustment was probably automatic, controled by thermostat, but there must be a manual operation of some kind. And sure enough, there was a graduated dial ranging from "H" through "N" to "C"—Hot, Neutral, and Cold, most likely. Beside it was an Off-On switch, and he tentatively poked it and waited for results. Nothing.

He studied the panel. There were other dials and buttons, some marked with letters or symbols which meant nothing to him. But there were two large buttons, one red and one black, at the extreme right-hand side of the panel, which could have only one meaning. He punched the black one, and was rewarded by a feeling of vibration in the suit. Then he tried the temperature "On" switch again, and turned the dial full over to "C."

He felt nothing, but in a moment frost began to form on the exposed inner surface of the suit. He exulted. Experimentation with the dial would lead him to the proper setting for comfort. He put his arms into the suit's sleeves and prepared to pull the garment up over his shoulders, then stopped.

The hands! Massive, heavily gloved things. Adequate, perhaps, for handling heavy objects and some not-too-small controls and instruments. But he'd never be able to assemble the tiny broken fragments of a head globe! Then he smiled. Part of a refrigerator was better than none, he reflected. He shuffled to the cabinet which contained climbing gear and similar apparatus, and took out a short length of cord. This he rigged to the spacesuit as a kind of suspender, raising the suit almost to his shoulders and yet leaving his arms free. Almost at once the oppressive outside heat seemed less, and its ef-



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fect on his arms, shoulders and head was fairly well neutralized by his own bloodstream circulating from the cooling parts encased in the suit.

There were tubes of plastic cement among the crew's tools, as he had been certain there would be, and shortly he had replaced several of the large pieces that had been broken out of the head globe. Now the task became more difficult as he sorted the fragments over and over in search of proper parts. As he worked, he considered with detachment the matter of six spacesuits on a clipper carrying thirty-odd. There must be a valid reason, he assured himself. Six suits would just about take care of the crew and nobody else.

After all, clippers made only short runs. Generally they were quite safe—barring such unexpected accidents as collision with an asteroid where no asteroid had any business being. But from time to time, he supposed, it might be necessary for one or more members of the crew to go outside for emergency repairs. And the clipper was more or less home to the crew. Each would logically have his own suit—probably belonged to him personally. Professionals in every field are like that when it comes to personal gear or equipment.

But six suits? That would include the stewardess, too. What reason would she ever have for . . . wait a minute! A sickening realization hit him. *Six* spacesuits, *six* Thorsen guns, *six* Gado pistols—and one, two, three, four, *five* crew members! He ticked them off on his fingers: Pilot, co-pilot, astrogator, communications, stewardess. That made five. But wasn't there an engineer on one of these ships? *What about the engineer, the sixth man?*

There had to be one. He knew it instinctively. And where would the man most likely be? Aft, of course. In the power room somewhere back there.

He dropped the head globe, not caring that several of the carefully fitted pieces broke loose and fell off again. He stumbled over the feet of his spacesuit, ripped off the improvised suspender and struggled all the way into the suit. He got the shoulder fastenings together well enough, clumsily in the heavy gloves, and hurried through the open door.

He picked his way back through the torn and twisted Passengers Section, past the stewardess' pantry, and halted at last before a door plainly labeled "Do Not Enter." He tried the handle, found it locked.

He tried to rattle the door, but it was evidently an air-sealed hatch. He pounded on it until his hands and arms ached, but could only fancy that he heard a movement of some sort inside. He kicked it, beat on it with a piece of metal picked up from the floor, then remembered the keys he'd taken from the crew.

In a moment he was back with the



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keys—eight small rings of them. Some looked like house keys. Spacemen had homes and families too, he supposed, though he'd never given it much thought before. Other keys looked like—but never mind that. At least one of them had to unlock this door. Had to!

He examined the lock. It took a tri-side key, and that eliminated three complete rings and most of the keys on the remaining rings. He tried one. Too small. But sizes are sometimes deceptive, especially in keys.

He tried another, and another. One slid in but would not turn. Patience was returning now, and logic. He wrenched that key from its ring and laid it carefully beside his foot. He tried another, discarded it and took up the next. Only one tri-side key here, and it fit—but it also would not turn the lock. He put it beside the first key. Time for violence later, if none of the keys worked.

Again he thought he heard a sound behind the door, and his excitement increased. Seven rings of keys were now discarded, and he had four tri-side keys—each from a different ring—which fit the lock but would not turn it. He quickly ran through the keys on the remaining ring, and tossed it aside.

Four rings, four keys, four crewmen. The logic of it was inescapable. He picked up the keys and compared them. They were identical.

He inserted a key and tried again without success. He tried it while lifting up on the handle, while pulling out on it, while pressing down. He tried turning the handle while twisting the key, and he tried kicking on the door as he twisted key and handle both separately and simultaneously.

And as he stopped to rest and devise other means of attack, he heard an answering thump from inside the power room.

There *was* someone! Someone else on this lost world! He cried out, and his eardrums popped—he'd forgotten about his oxygen mask. He ripped the face-piece off and let it dangle.

"Hello-o-o-o!" He shouted. "Who's there?"

The thump came again, and he thought he heard a muffled cry from within. He put his ear to the door—nothing!

He called out again, and listened intently.

This time it was real, but the voice was either very weak or rendered so by its passage through the door.

"Hello! Can't hear you!" he yelled, and paused with his ear at the door.

Weakly, indistinctly, he made out the words: "Open up, hurry!"

He cupped his hands into a megaphone at the door seam, and shouted again. It didn't seem to him that he made as much noise, but he hoped it would be more penetrating.

"Keys won't work," he called. "How do I open the door?"

"Jammed," the words came faintly



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from inside. "Can . . . pry the door up?"

He stepped back and inspected the door. Sure enough, it was slightly askew in its frame, the bottom being lower on the right than on the left.

"Hang on, I'll try!" he shouted, then sought among the wreckage for a piece of metal suitable to make a wedge or a pry.

He found what he wanted. Using another piece of scrap as a hammer, he knocked a small wedge in under the door where the separation was greatest. Then, slowly and carefully, he pounded it sidewise along the door frame.

It was tedious work. Once the wedge slipped out altogether, and on the next try he used a second and larger wedge to follow along as a safety.

After every few blows he tried the key again. And at last, to his relief, the key turned in the lock and he yanked the door open. A rush of air from within the room nearly knocked him off his feet, and hurled the door against him.

"Inside, and close the door, quick!" the power room's occupant cried as his rescuer peered in. "What have you out there, a blast furnace?"

A man lay sprawled on the floor, one leg twisted awkwardly. "Busted," he explained, gesturing with his right hand. Then, with a grimace of pain, he added, "This one, too, I think," and pointed to his left arm.

For a long minute the two looked at each other silently, then the passenger knelt beside the prostrate crewman.

"Let's see about your injuries," he said. "You're the engineer, aren't you?"

"Right," the man acknowledged. "Name's Aiken—John Aiken. But I can wait for the Doc to fix me up. I've waited this long . . . a little more won't hurt much. What ship you from?"

"There won't be any doctor—for a while, at least." Carefully and gently he undid the other's clothing fastenings. "And there isn't any other ship. I'm only one of the passengers on this clipper."

Aiken paled. "Then, the other—?" His voice trailed off as the passenger nodded his head.

"All dead, every one of them. All except the two of us." He felt along the man's leg, then straightened up.

"I don't know much about such things," he confessed, "but at least it's not a complicated break—not a . . . what do they call it? . . . compound fracture. We ought to be able to rig up a splint of some sort."

He turned his attentions to the crewman's arm. As he examined the injury, his mind worked feverishly on the matter of these new developments and their implications. He felt good about having someone *alive* with him, even if that someone's con-



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dition did add to the existing problems. Also, the fellow was a spaceman. He'd know things that could be very important to their survival.

The engineer, too, was thinking. He lay silent, staring at the ceiling until the passenger had finished his examination.

"All dead," he said at last. "Just the two of us, right?"

The passenger nodded. "First thing," he suggested, "we'd better get those broken bones set so you maybe can get around a little bit. Then we can talk, and figure out what to do next."

Aiken directed him to the first-aid cabinet, which he saw was oddly located at floor level. It was open. He looked at the engineer, puzzled.

The spaceman grinned. "One of the smartest things they ever did, putting that cabinet next to the deck. How else could a banged-up guy like me get at it? I've already been at the morphine. The pain was pretty bad for a while."

He gritted his teeth as the passenger worked, and presently the job was done and he could sit up with little pain.

"Well, now," he said, "this is more like it." Then, after a momentary pause, he asked, "You got a name, buddy? Can't be calling you 'Hey' or 'You' if we're going to be stuck here any length of time."

The passenger laughed, introduced



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himself as Philip Jennings, and the two shook hands in mock formality. Then he got food for his companion and brought it back into the power room.

There was insulation from the heat in the power room, and Jennings turned his temperature control to Neutral. Presumably there would be insulation from the cold as well, and he asked Aiken about this. The engineer assured him that he'd felt no appreciable temperature changes while locked in the room, and that air pressure had been steady and comfortable.

As the crewman ate—and he wolfed his food like a starving man—Jennings described their circumstances as best he could, and recounted his own activities and discoveries thus far. The engineer nodded appreciatively.

"For an amateur—and a groundlubber at that—you've done right well," he observed. Then, after thinking for a moment and licking the last bits of food from his fingers, he asked, "When do you figure it'll be cool enough so I can have a look around? Judging from the blast of heat you let in through that door, it's no place out there for a sick man."

Jennings consulted his watch. It was nearly 0700. Dawn had come at 0230, which meant that sunset would follow sometime around 1000 or 1030. It would begin cooling off shortly before that, maybe a half-hour. He decided, then, that it would be cool enough in from two to two-and-a-half hours. Aiken wound and set his own watch.

"If you don't mind," he said, "I'd like to lie down again and take a little nap. With that food in me, and the arm and leg not hurting so much, I think I might be able to rest a little. You wake me when it's time?"

The passenger agreed, though he felt somewhat drowsy himself. He'd been on the go steadily for—how long? —about twenty-two hours since his last nap, and had exerted himself considerably in that time. And this pure oxygen he'd been taking seemed to burn up energy at an alarming rate. However, another two or three hours wouldn't make much difference. Perhaps he could sleep while Aiken worked at whatever engineers did.

It was comfortable in the power room, and he was glad of the opportunity to get out of his cumbersome spacesuit and survival suit. He stretched, and scratched himself, and then continued his exploration of the clipper.

The power room was well insulated. For the time being, then, he could dismiss his plan to move into a cave. And that was a relief, for the problem of moving the injured Aiken was greater than he wanted to tackle. If and when the power supply gave out, or the air supply, then they could make their move. But in the meantime, this would be much more comfortable. He made a mental note to



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ask the engineer about such things.

From one end to the other, the power room was only about four meters long. But in the absence of any visible machinery he decided that it was probably a sort of office and storage compartment presided over by the engineer. The power units themselves must be farther aft. Cabinets along the walls bore out his theory, and a door at the far end of the room was marked with a warning to unauthorized persons to keep out.

He knew enough about atomic radiation to heed the warning, and decided there was little he could learn from examining any generating apparatus. Of more interest was another small door which had no sign, and which he happily discovered concealed a rest room.

Later, he explored the cabinets which lined both sides of the power room, and found a veritable treasure in tools, equipment, and apparatus of undoubtedly great importance to anyone who knew what it was for. Time passed quickly, and when next he looked at his watch it was 0854. He stepped over the engineer, who snored peacefully despite his hurts, and carefully opened the door to Passengers Section. His banging and pounding on the door to open it the first time had evidently sprung it back into place, for now it worked easily.

A rush of escaping air reminded him of the low pressure outside, and he pulled the door to. Reluctantly, he climbed back into the survival suit, adjusted his oxygen mask, and got out of the room quickly with as little loss of air as possible.

It was cooler already. He climbed on one of the seats and looked out through a torn opening. The sun was low on the horizon—and now, since he knew comparative sizes of the rocks and ridges from having climbed among them, he could tell that the horizon was not far away. A few hundred meters, at most, which of course meant that this planetoid—or whatever it might be—was a tiny thing compared to Earth, or even Earth's Moon. Tiny but dense, obviously, since it had a gravity that was far out of proportion to its size.

He went back and awakened Aiken. Time was running out, and soon it might be too cold for the engineer. But the crewman shrugged at this.

"You just get me into a spacesuit," he said, "and I'll be O.K. No survival suit, mind you. Just the spacesuit. I'd never be able to get this arm and leg into a survival suit."

Jennings went forward again and returned with a spacesuit and an extra hood, mask and canister from a survival suit. And at last, after much groaning and wincing at the pain, Aiken was dressed and able to hobble, supported by the passenger, through the door and on to the pilots' compartment.

"A mess, right enough," he said as he surveyed the wreckage. His eyes



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lingered on the stains that Jennings had not been able to clean up; then he pulled himself to the pilots' door and peered down.

After a moment he turned away, looking pale and a little sick.

"Can you close that thing?" he asked. "They were friends of mine."

Jennings replaced the hatch cover, and when he had finished he helped Aiken to the controls.

The engineer pressed a series of buttons, one after another. "Control check," he explained as he noticed Jennings watching with interest. "These buttons don't actually work anything. They just indicate whether something else *will* work. See these lights?"

He pointed to a small bank of lenses above the buttons. Two were illuminated. Aiken punched another button.

"Nothing" said. Then another, and another, ch time with a shake of his head.

The next button lit up a third red light, and when the spaceman had completed his "control check" there were seven red lights shining above the instrument panel.

"Not good," he said, "but really better than I expected. She won't fly, but she can talk. We ought to be able to communicate, if we can pick up anybody."

He pressed another button, one slightly below the series just tested, and a tiny amber bull's-eye flashed on. He reached for a large knob on the panel, hesitated, and turned to Jennings.

"That knob is a directional control," he explained. "Space is big, and we're awfully small. If we focus in a tight beam, we've got power enough to broadcast for quite a distance. Broadcast wide open and we get nowhere—or if we do, it bounces off planets and asteroids and whatnot so nobody can get a directional fix."

"Well, what's the matter?" asked Jennings. "Is there something wrong with it?"

Aiken shrugged, and winced at the pain it caused in his broken arm. "Which way do you suppose we should aim the beam? What would be a good direction? Do you have any idea where we are?"

Jennings sat down in what he supposed was the co-pilot's seat. He had hoped desperately that Aiken, being a spaceman, would know the answers to such things. But, after all, the man was an engineer—not an astrogator.

"Isn't there a compass of some sort?" he asked after a bit. "I don't know exactly what, but isn't there something—?"

"Busted," the engineer replied tersely. Then he looked up. "Say, there is something. Maybe we could . . . yeah, it might just work!"

At the crewman's direction, Jennings returned to the power room. In one of the cabinets was a device which Aiken referred to as a Trip-



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Graph. Under its transparent cover he could see that it was a stylographic machine of some sort, recording data by means of two heavy black lines traced over a finely ruled grid system.

He lifted the cover, found a pair of release clamps that had been described to him by the engineer, and lifted out the drum of inscribed charting. A knife-edge in the machine's lid cut the drum free for him, and he carried it back to the pilots' compartment where Aiken had him unroll a meter or two of it.

The two lines, Aiken explained, indicated time-distance factors in their trip. One showed time-distance from take-off, the other marked approximate distance from the Sun. Jennings followed this easily enough once the function was explained.

At a little past 2000 hours Earth time, he observed, both tracings had abruptly halted their slanting march across the graph. That time could only be the moment of crash. And the distance traveled from Earth up to that point was shown at slightly over eleven hundred million kilometers.

In a few minutes of calculation, the facts began to fit together. The astrogator's plotting table was a shambles, but from the wreckage Jennings was able to retrieve a drawing compass, a straight-edge, and a torn pad of graph paper.

With the engineer calling off figures from memory, Jennings constructed a rough scale-drawing of the inner solar system orbits.

"Now stick Earth in there anywhere on her orbit," Aiken directed. "We can work from there."

Jennings did so, located an arbitrary point on the circle indicating Earth's orbit, and marked it with a large dot. Then the spaceman told him to measure off on the straight-edge a distance corresponding to thirty-two hundred million kilometers.

"Thirty-two hundred million?" Jennings echoed. "Why, Earth is only about fifteen hundred million from the Sun!"

"Right enough," the engineer replied, "but remember, we were chasing Mars on this trip and she was about a third of the way around the system from us when we started. You'll see how this works as we go along. Now go ahead and measure off that distance, and then draw a straight line exactly that long—starting at Earth and ending at the orbit of Mars."

Again the passenger looked perplexed. "But how is a straight line going to help us? Aren't these flights plotted in curves? I know they are on Earth, for ocean ships and aircraft."

Aiken sighed. "No. And they're not curved on Earth, either. They only seem to be because of the rectangular grid system used for mapping and charting. A straight line between two points on an Earth map would appear curved—or, what I



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mean to say is, it would *be* curved because of the distortions in the map.

"In space, everything is based on the plane of the ecliptic—and for our purposes that's as flat as a table top. And distances are computed from where Earth *was* and where Mars is *going to be*, all in a straight line. Get the idea?"

Jennings nodded slowly. "I think so," he said, and then proceeded with the task of measuring off the distance. Cursing the clumsiness of his gloved fingers, he laid the distance off on the chart and found that it crossed well into the orbit of Venus and, as the engineer had predicted, terminated at a point in Mars' orbit about one third of the way around the system from Earth.

Next he marked off the ship-Earth and ship-Sun distances as shown on the Trip-Graph, and found that they coincided on the line Earth-Mars. Aiken smiled in triumph.

"Just like I figured," he said. "You know, I think I missed my calling. That's where we are—or at least it's where we were when we crashed. And my guess is that we're probably somewhere in the same vicinity. We'll have to hope so, anyway."

Then his smile faded. "But what good does it do us?" he groaned. "So we have a fair idea where we are, give or take a few thousand kilometers, how do we figure direction from here? This crazy rock may rotate from east to west or top to bottom! Which way is Earth—which way is up?"

But by this time Jennings had caught the spirit of the engineer's calculations and his line of thought.

"Look," he exclaimed, "if we're located about here"—he drew a tiny circle at the impact-point—"and if we rotate from west to east like a normal planet, then Earth is in the direction of 'straight up' from here right now."

The engineer raised an eyebrow. "I don't follow you."

Jennings went on. "Looking from solar north down, Earth's going around the Sun counterclockwise, right?"

Aiken nodded.

"O.K. Then Venus is going around counterclockwise, and Mars, and just about everything of importance in the system. Check?"

The spaceman agreed.

"So here is our asteroid." He drew a line across it, and shaded in the half which faced away from the Sun. "The line of day-night demarcation parallels the Earth-Mars line, doesn't it?"

After a moment of pained thought, Aiken nodded again.

"Don't you get it?" Jennings fairly shouted. "If we rotate west-east, we're looking up at Earth just after sunset. If we rotate east-west, it's just before sunrise. And if we rotate head-over-heels or vice versa, Earth is always at right angles to the path of the Sun. That way we can . . . oh . . . I see what you mean!"



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The engineer smiled without enthusiasm. "We can be rotating on an axis that has one hundred eighty degrees of angle to pick from—three hundred sixty degrees, really, when you figure we don't know up from down."

Jennings leaned back in the copilot's seat. His brain was whirling now. In his mind the stars and the sun crisscrossed in fantastic patterns. And then suddenly he saw the answer.

If the asteroid rotated end over end—or in any way greatly different from Earth's rotation—then some familiar stellar constellations would have appeared during the night. None had. Not a single one.

The same thing would be true on Earth, far in the Southern Hemisphere. There'd be the Southern Cross and other constellations he'd heard about but never seen, and his familiar Pole Star would be invisible.

In other words, the axis of this asteroid *must* be tilted at nearly the same angle as Earth's, and they *must* be located somewhere in the southern portion.

He checked this with Aiken, who agreed and showed new interest in the problem. All that was needed, then, was a general direction toward Earth, Venus or Mars. It needn't be a direct line. Space traffic would pick it up if only it were beamed to the zone of space travel.

Further calculations produced seemingly usable results, after the probable "now" positions of Earth and Mars had been plotted. They dismissed Venus after finding that a direct line to her ran too close to the Sun.

Jennings then helped with the directional control, and also with the adjustment of other knobs and dials that proved too much for the disabled engineer to handle. Then, after making Aiken as comfortable as possible at the control panel, he got into his spacesuit and settled down in the copilot's seat again.

Biting cold had returned again, unnoticed in the excitement of their work, and he turned up the temperature control a bit. He watched Aiken for a few minutes, but presently the transmitter's buzzing made his eyelids heavy. Once he shook himself awake to ask why the engineer was tapping out code instead of using voice transmission, but hardly heard the man's explanation.

Minutes—or hours—later he awoke suddenly to hear the compartment filled with sound. Over the buzzing, roaring and popping of space-static, he could hear faintly the sound of a human voice.

"Aiken!" he cried out, dragging himself from sleep. "What are they saying? Who are—" he stopped suddenly and peered at the engineer.

The spaceman was slumped in his seat. Panic filled the passenger, until



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he discovered that the man was unconscious but alive. Not too surprising, now that Jennings thought about it. For a man with two broken limbs, the engineer had performed a formidable task.

He left the crewman for a moment, and bent close to the amplifier. Holding his ear close, he could barely distinguish words.

He hesitated at the amplifier control, not sure of himself. Was it *that* knob, or was it the next one? If he were wrong, and he tuned to a different frequency—or altered the angle of the carrier beam—he might never regain contact.

But he had to know. And then, on second thought, he realized that he could turn the knob back again as easily as he turned it forward. He twisted it ever so slightly, and the cabin rang with the reverberations of increased volume. Aiken groaned, but remained unconscious.

"Come in Clipper 42-Y-17—" the voice was repeating over and over. That was *this* ship, Jennings exulted. Aiken had made contact. They'd heard him, knew something was wrong.

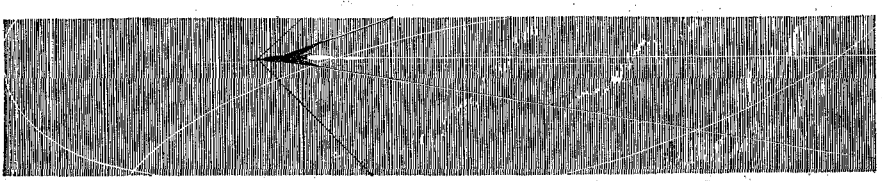
A wave of static drowned the voice momentarily, and when it came back again it was saying ". . . will be alongside at approximately 2300 hours. Can you hear me, 42-Y-17? Can you—" Again the voice faded, but Jennings had heard enough. He turned the volume back down, and looked at his wrist to see the time—only to discover that this time the watch was inside his spacesuit.

He shrugged. What difference did it make, anyway? 2300 hours could be within the next few minutes, or late tomorrow. But they were coming.

He turned his attentions to the stricken engineer. Cautiously, gently as possible in his cumbersome spacesuit, he got the man out of the pilot's seat and half-carried, half-dragged him back to the power room where he did his best to make him comfortable.

Then, helping himself to what he hoped would be his last free meal, he sat down again to wait.

THE END





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An ASF Factual Article

# LOCUM TENENS

*"**Steel:** An iron alloy . . ." used to be the definition. Now it's made of a score of metals, and iron isn't the dominant one in some of those "steels." Iron is being displaced also in the jobs steel used to monopolize.*

## BY WALLACE WEST

History can be written in terms of the substitutes men have dreamed up, on occasion, to replace the tools, weapons, shelters, customs and even the religions that served their forefathers for ages. This evolution, progress, survival-of-the-fittest or whatyoumaycallit never has proceeded at a steady pace. Neither has it been motivated entirely by hunger: Time after time whole peoples have starved or allowed themselves to be massacred rather than make some comparatively slight adjustment to environment. No, it has come by fits and starts as though, ever so often Man has been prodded by pure boredom—or mutated genes—to change his surroundings in a great hurry.

Consider the time when man first cracked an atom. . . . No, let's start with Act I of this extraordinary show and consider the time when he first cracked a skull. He climbed out of a tree, substituted semi-intelligible grunts for emotional howls, found a cave, built a fire, exchanged claw for club—and fought his way to the top of the animal kingdom so fast that archeologists never have managed to spot him on the way up. After that, though, he sat around for several hundred thousand years, chipping flints, making his frowning Neanderthal competitors say "uncle," drawing some pretty pictures on his cave walls —but never discovering perspective—and only in recent times solving the simple problem of putting a polish on stone.

About eight thousand years ago—at the start of that heliolithic age which Robert E. Howard loved to romance about—mankind exploded again for no apparent reason. The glaciers were receding and the weather was warmer than it had been for eons. Hunting and fishing must have pro-



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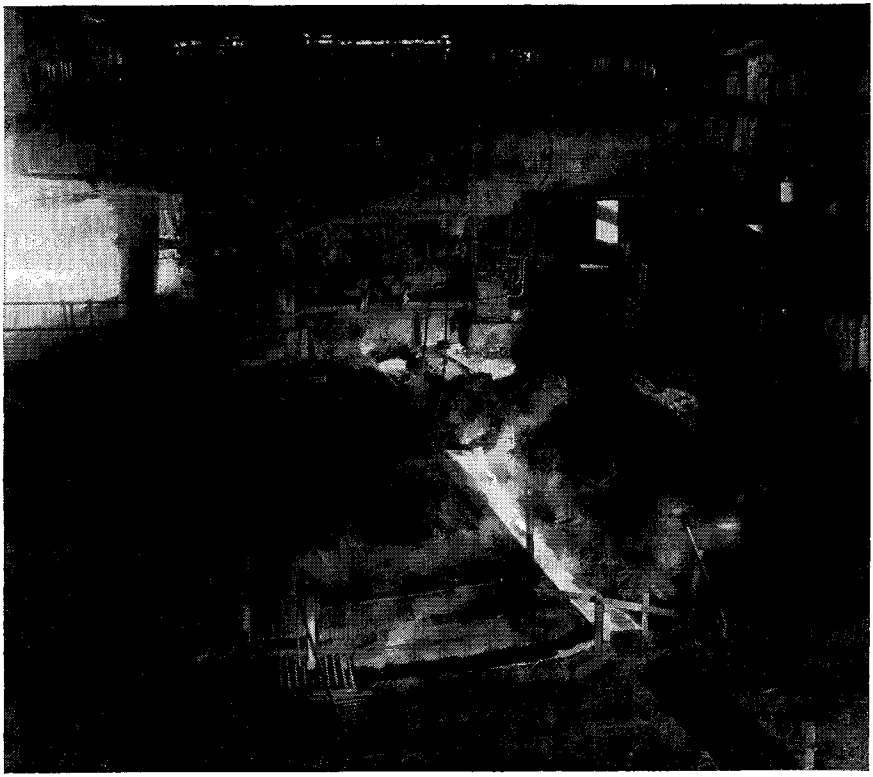

INLAND STEEL CO.

**Of all the processes of Man's industry, none is more spectacular than that of making steel. From the huge furnaces that turn out brooklets of steel onward, the processes are big, violent and spectacular.**

vided a reasonably adequate food supply under those circumstances. It was a time to take things easy. Instead, in a fantastically brief period, men learned to tame horses instead of eating them and invented the wheel to make proper use of both animal and water power.

These dawn men mastered the highly complicated arts of irrigation and agriculture. In Sumerian Mesopotamia they built the world's first cities out of sun-baked brick. They found out how to smelt copper. And they began to pass on accumulated knowledge from generation to generation by means of picture writing.

Again there was a pause for refreshment—comparatively short but probably the only period in history when the whole world was at peace. Then, around 2,000 B.C., the calm was shat-



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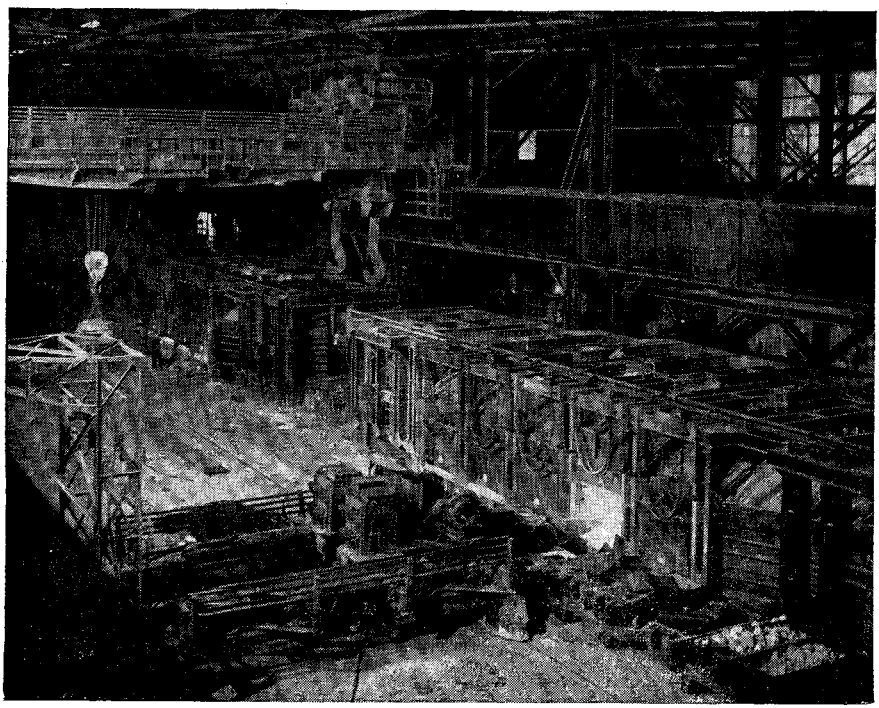

CORNELIUS

**The robots of the steel industry are big and powerful. A massive steel arm reaches into the blazing hearth furnace to dump a load of scrap steel into the melt; other "handfuls" wait to be picked up and dumped.**

tered when bronze implements and the alphabet were introduced.

As with most modern inventions, there are many claimants for the honor of being first with those ancient ones. Palestine seems to have the inside track with the alphabet although further investigation may show that Crete had it earlier. However that may be, the new type of writing spread like wildfire along the trade routes of the world. Only the Chinese clung to ideographs and that stubbornness had much to do with ending the preeminence that China held in the ancient world.

Egypt, Crete, Asia Minor, Mesopotamia, China or the land that is now called Hungary may have given birth to the genius who noticed that a little tin mixed with copper made a tough, strong metal that could be cast into intricate shapes. (India takes full credit for the discovery of brass, an alloy of copper and zinc that has many of bronze's properties.)



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But only Hyperboreans, or Achaeans, of prehistoric Hungary grasped one all-important fact: A sword made of fire-hardened bronze held an edge better than any weapon previously forged. Whereupon they started an invasion of the lush, semicivilized lands to the south. Their forays continued for a thousand years until they had conquered most of Greece, toppled the towers of Troy and laid waste mighty Crete. Savagery threatened to engulf the known world.

Circa 1,000 B.C., when it seemed the virile Hungarian wielders of wicked, leaf-shaped bronze swords might sweep across or around the Mediterranean, another explosion occurred in two widely-separated lands. The Minoans of fire-blackened Crete in front of the invaders and natives of Austria and South Germany on their exposed right flank learned how to substitute plentiful iron for scarce copper, tin and zinc.

They didn't smelt ore as we do, separating vast quantities of metal from slag with lime flux and coke fuel brought to white heat by blasts of air. They built a charcoal fire over a trench filled with red "paint rock." They may have blown air into the coals through long bones or wooden tubes; this created a spongy hunk of melted iron mixed with slag. Then they "wrought" this sponge by beating most of the slag out of it with hammers. They quenched the red-hot metal in water or oil to give it a hardness and toughness that put to shame even the rare and then largely accidental phosphor-bronzes. And shortly the smiths of Gnossus in Crete and Damascus in Syria got the hang of packing wrought iron in pure carbon, remelting it, and making steel that equals some of the best modern alloys.

Credit for the first working of iron in Crete—like most other scientific and artistic achievements in the later days of that mysterious island—is given to a Greek DP named Daedalus. Legend has it that this architect, sculptor (and time traveler, could it be?) committed a murder and had to flee his native land. The last King Minos, who was doing his best to patch up the damage to his realm that had been caused by the wars with the Hyperboreans, hired Daedalus to build an elaborate labyrinth on the palace grounds.

To adorn the place, Daedalus made some rather extraordinary bronze statues; so extraordinary, in fact, that he had to chain them to their pedestals to keep them from running away! When the Argonauts first appeared off the coast of Crete, the sculptor loosed one of his robot statues. It licked Theseus, Hercules and the rest of those Greek heroes singlehanded, say the old chroniclers.

Next, the legends insist, Daedalus found out how to work iron. Then, over the protests of the king but with the connivance of Queen Pasiphae,



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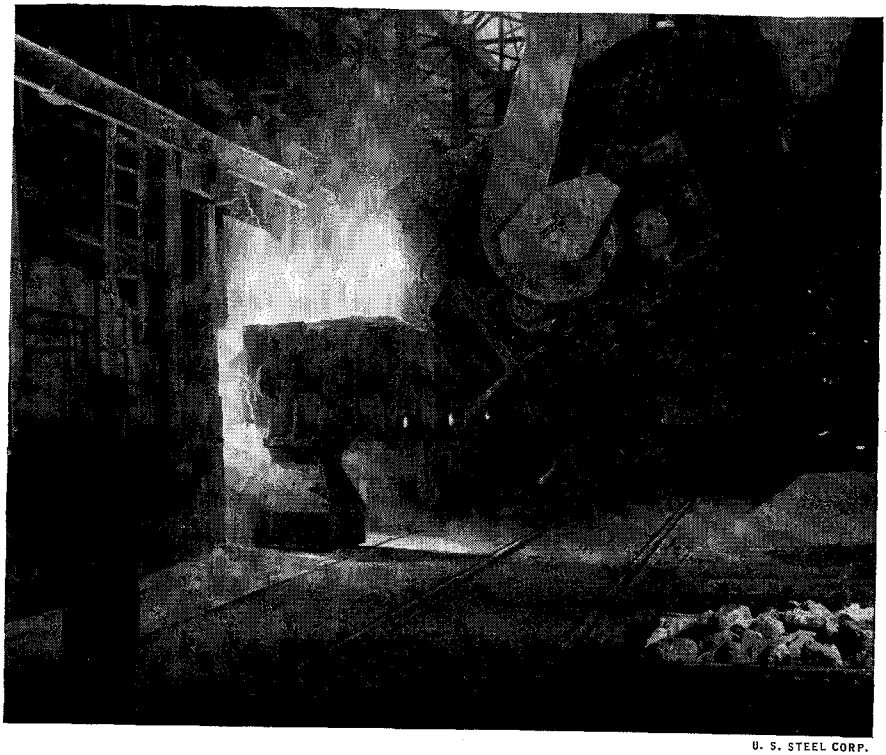

U. S. STEEL CORP.

Across the page, aluminum is being poured into molds; here steel pours into an open hearth furnace—100 tons of incandescent metal in a giant's bucket.

he almost emptied the royal treasury in order to build a fire-breathing monster for the labyrinth. (Could it conceivably have been a steam power plant to replace Crete's slave power that had been carried off by the northern invaders? Hero, a Greek engineer at Alexandria, built a steam turbine of metal not too many years later. It was never developed commercially, probably because slave labor and machinery do not mix.)

For all his ingenuity, Daedalus missed the one important point: Iron weapons take a much sharper edge than bronze ones do.

The Austrians of those days were Celts and apparently as pugnacious as their descendants. As soon as they learned to work iron they whipped up battle axes and such, smote their Hungarian neighbors hip and thigh, and took over the latter's conquests until such time as they could discover



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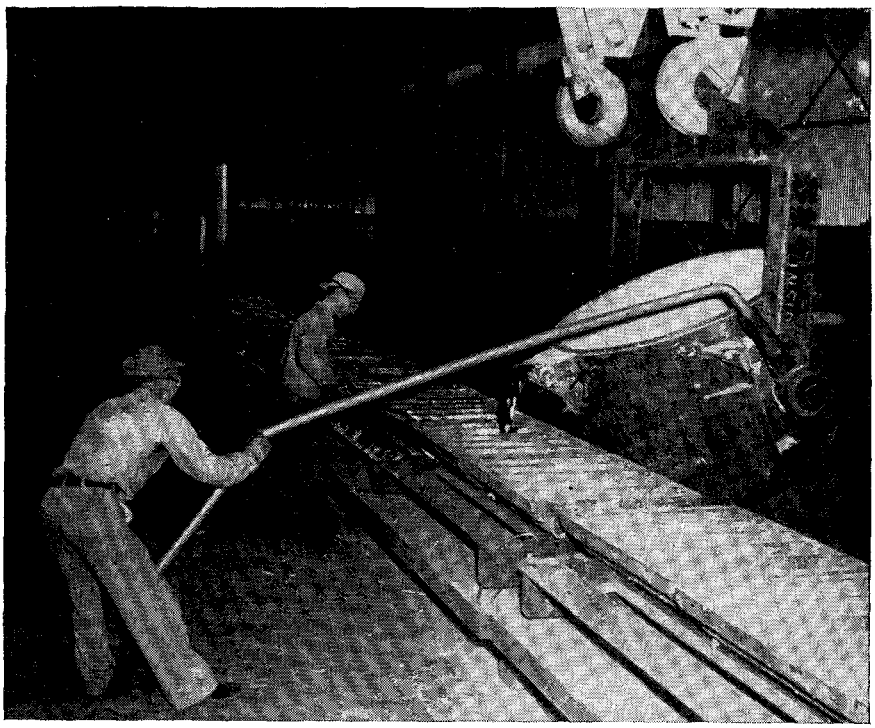

ALUMINUM COMPANY OF AMERICA

**The aluminum industry has grown immensely, but it's not on the same scale as steel. The contrast in size and violence shows clearly in these two photographs of pouring molten metal.**

Ireland. *

So the Argonauts or their Celtic successors came back to Crete armed with iron weapons. Men of bronze could not stand against them. Gnossus went up in smoke for the last time. But, the Greek chroniclers are unanimous in agreeing, Daedalus whipped up an airplane, or at least a glider, and escaped to Sicily. (The ship he made for his son, Icarus, caught fire and crashed.)

A fantastic interpretation? It becomes even more remarkable when

* There had been a few iron weapons, tools and ornaments knocking around the Mediterranean area for thousands of years before this. Apparently the art of working that metal had been discovered and lost repeatedly due to poor communication and the lack of accurate written records. Some early wrought-iron swords became sacred objects because of their extreme sharpness. It is likely they were hammered out of chunks of meteoric nickel-iron. King Arthur's first Excalibur—he had two magic weapons, both called Excalibur, a corruption of the Celtic "caladbolg" or "sword of heroes"—is a case in point. The young king, you remember, pulled it out of the middle of a black stone. It also is possible that the second Excalibur, which rose out the waters of a lake, is a reminder that iron weapons had to be quenched or tempered to make them hold an edge.



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you realize that all of those stories about Daedalus were recorded by Greeks. The latter hated everything remotely Cretan because, for several millennia, the islanders had made it a habit to raid the mainland and carry off the prettiest Greek girls. Some day, when a new Champollion appears to translate the voluminous written records of Crete as his predecessor did Egypt's hieroglyphs, the true story of Daedalus may be told. It may well make the adventures, inventions and artistic achievements of Leonardo da Vinci look pale.

But enough of speculation. The remainder of this article will deal entirely with hard facts—the harder the better!

For a few centuries after 1,000 B.C., it looked as though the rapidly spreading use of iron might usher in the Golden Age men always had dreamed of. Iron opened new vistas in every direction, just as did the first demonstration of atomic fission three millennia later. But its use as an efficient tool soon was overshadowed by its value as a weapon. Iron Age culture peaked in the days of Pericles and democratic Athens. Then it nosedived as the result of civil wars, bloody conquests, the rise and fall of Roman imperialism and the onset of the Dark Ages.

Of course there was much banging around, particularly after the advent of Chinese gunpowder. Forgotten voyages of discovery by the Phoenicians, Greeks, Carthagenians and Cretans were duplicated in later ages. Considerable scientific information was accumulated but most of it lay, undigested, in the libraries of Alexandria and Constantinople. As a result of this semistagnation, the average European peasant of the fifteenth century lived almost exactly as his ancestors had done at the beginning of the Bronze Age.

Then, around 1450, Gutenberg touched off the next explosion by inventing movable type.

The coming of inexpensive, readily accessible books began the greatest change in all human experience. As soon as they were able to compare notes, alchemists became chemists, physicists or physicians. When they learned about the Arabic decimal system, mathematicians no longer had to spend four long years getting Ph.D.'s in multiplication or division as they had done during the Middle Ages when they were still struggling with Roman XCD's. The world became round again, for the first time since the fifth century before Christ.

The industrial revolution started after James Watt read about Hero's pioneer turbine and was encouraged thereby to invent a reciprocating steam engine.

But Watt's engines and the machines they ran required unheard-of amounts of iron and worth-its-weight-in-gold-or-gems steel in their manu-



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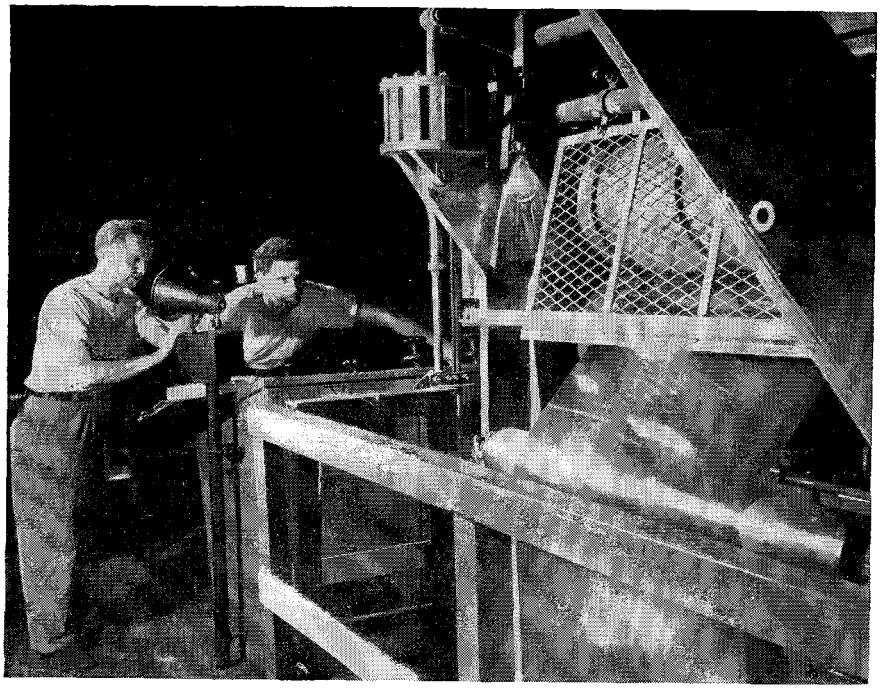

SCOTT-D'ARAZIEN

Steel needs help to resist corrosion; tin plate is the standard co-operative metallic system. Tin lacks strength, costs too much; steel is strong and cheap, but corrodes. With modern electroplating systems, one side of this plate is heavily tinned, the other lightly tinned. The heavy plating goes inside the can!

facture. The cramped fingers of the Fugger family and other middle European banker-monopolists eventually were pryed loose from the steel business and small foundries sprang up all over. Everything hummed with activity until—*Wham!*—the first industrial bottleneck developed. The new foundries consumed so much charcoal that they threatened to wipe out every forest on the continent.

It was in 1543 that British shipbuilders warned Parliament the ironmakers were robbing England of one hundred thousand oak trees yearly, enough to rebuild half the Royal Navy. After fifteen years of debate the lawmakers responded by forbidding the cutting of oak within fourteen miles of the coast or a navigable river. And in 1585, with the Spanish Armada gathering below the horizon, the panicked Parliamentarians made it illegal to put up a furnace or even a forge anywhere!

Still the forests dwindled until the



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price of charcoal constituted half the cost of making iron. Even at Saugus, Massachusetts, where the first successful American iron works was built around 1644, the ironmasters fretted over their wood supply.

A substitute was available but it was many decades before anyone stumbled upon it. In 1620, the year the Pilgrims landed on Plymouth Rock, an Englishman named Hugh Grundy invented "the charking of earth fuel"—and got one of the first patents ever granted on this process of making coke from coal. Not until 1708, however, did another Englishman, Abraham Darby, succeed in smelting good cast iron from the new fuel. Young Darby watched over his primitive blast furnace at Coalbrookdale, in Shropshire, for six days and nights while the test was being run. When he finally saw molten iron flow from the tap hole he "fell in a fit" that contributed to his death a few years later.

Darby's coke-fired blast furnace is a big boy now. It may cost between nine and eleven million dollars, depending on the amount of auxiliary equipment used. Often nearly one hundred feet high, it is a steel shell, lined with heat-resisting brick and capable of smelting one hundred to three hundred tons of pig iron every four or five hours.

Alternate layers of ore (1¾ tons), coke (1 ton) and limestone (½ ton) are fed in at the top of the furnace for each ton of iron to be made. Hot air (4½ tons per ton of iron) is blown in at the bottom.

The solid materials work their way downward, growing hotter as they continue. In the top half of the furnace, gas from the coke takes oxygen from the ore. Midway, the limestone reacts with impurities in the ore and coke to form a molten slag. Farther down, the coke becomes a paste while the iron turns into a porous mass and finally into a liquid. Ashes are absorbed by the slag while the iron picks up silicon from the slag and carbon from the coke.

At the bottom, the slag is drained for conversion into cement or insulating material. The iron also is drained and cast into pigs or is poured into a mixer car resembling a huge thermos bottle on wheels and delivered, white-hot, to a steel mill. About ten per cent of the nation's pig iron is made into castings. The rest is turned into steel.

It is difficult to realize today that, prior to 1870, steel remained an expensive rarity. Wrought iron was the aristocrat of working metals but it, too, was scarce and costly because it had to be "puddled" in small batches by highly skilled operators. Substitute processes of manufacture had to be found if industrial progress were to continue.

Once again, two inventors stepped forward with different solutions. In 1856 Henry Bessemer unveiled his



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spectacular converter. And in 1867 another Englishman, Sir Charles William Siemens, completed his first successful open hearth steel furnace.

Bessemer's baby, which behaves like a V-2 rocket taking off, became the steel industry's matinee idol despite the fact that it had—and still has—a number of serious faults. By 1866, converters were making eighty-six per cent of the steel poured in America. Hardly a week passed without *Harper's Weekly* or some other popular magazine running a series of lurid drawings showing the contraption going through its paces.

While the Bessemer is horizontal a huge ladle half-fills the refractory-lined steel retort with from five to twenty-five tons of molten pig iron. A whirlwind of air is forced through the charge. As silicon and manganese are oxidized sparks shower and ruddy flames appear. At this, a skilled workman known as a "blower" who controls the blast from a "pulpit" high above, tilts the converter on its big trunnions so that the flame is vertical. The flames turn yellow as silicon takes fire, then white as carbon is oxidized. Carbon monoxide escapes with a roar that lights the countryside for miles. Then the flame drops, a warning to the blower that the iron itself is about to catch fire. He reduces the air pressure and pours pure steel into a ladle. The show is over.

Despite the high jinks it performs, the Bessemer has lost out to the more prosaic open hearth furnace. Today the latter makes about ninety per cent of America's steel while the converter specializes in free-machining steels and those used for some kinds of wire and pipe.

One big reason why the open hearth has grown in favor is that it can use large quantities of scrap steel—and scrap has become the lifeblood of the industry. Because of this ability, today's junk becomes tomorrow's limousine and the average furnace charge is close to half scrap.

An open-hearth furnace resembles a giant salad mixing bowl or an indoor swimming pool for a salamander. A 70′ by 20′ basin is fed with lime and compressed steel scrap by means of a mechanical charger. This monster thrusts its blunt head through various small doors along one side of the furnace, ignoring the roaring flames that sweep back and forth over the charge. Molten pig iron is charged from a large ladle.

A melter, one of the few humans in evidence, keeps close watch over the seething batch by means of a remote-control panel complete with a television screen. Like a French chef he takes frequent samples and adds lime or other elements until he gets exactly the analysis ordered by the customer.

Twelve hours after cooking starts, the open hearth is tapped by means of a sort of bazooka that blows a neat hole through a ceramic plug in the farther



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wall. As the steel pours out into a ladle a workman shovels into it the few pounds of alloying materials that finally help determine whether the metal shall be tough, brittle, "soft" or diamond hard.

Sounds impressive, doesn't it? The fact is, however, that open hearth furnaces are being improved continuously. They are still too slow because they work by the batch, instead of a continuous process. And some experts think the temperature at which they operate is so high that it reduces the quality of the steel.

Extensive research is going on looking toward development of a low temperature, beltline method of making steel. The difficulty is that untold millions of dollars are invested in open-hearth furnaces. It is going to be mighty difficult to convince the owners of steel company stock that such a vast amount of capital should be written off the books by junking the old stand-bys for a new and untried system.

A partial stop-gap answer to the problem has been found in the electric furnace. Steels poured from this comparatively new monster are the thoroughbreds of the industry. The reason for this is that the electrics charge pedigreed scrap. Their production is only seven per cent of the nation's total steel but they turn out the bulk of bluebloods like stainless and heat-resistants and alloys for bearings, tools, magnets and jet engine parts.

Electric furnaces are drum-shaped steel retorts set on rockers and pierced, at the top, by carbon electrodes seventeen inches or more in diameter. Each consumes enough power to meet the electrical needs of thirty thousand homes. Each produces more than one hundred tons of the finest steel every eight hours while using only small quantities of America's dwindling iron ore supply.

Steel from the electrics, open hearths and Bessemers is commonly cast into ingots a foot and a half to a yard wide and six feet high. Ingots are formed in cast-iron molds and are, in general, a howling nuisance. They cool from the outside inward with the result that their "skins" have different characteristics from their interiors. They shrink and develop holes or "pipes" that have to be filled with more hot metal or cut off in rolling and sent to the scrap pile. They hold up production while they repose in "soaking pits." There they are heated to 2200 degrees by oil or gas until they are of uniform temperature throughout.

Three competing methods of avoiding this bottleneck are being tested. They involve continuous casting through a bottomless, water-cooled mold. Steel poured steadily into the top is withdrawn at the bottom at the same rate. Junked pipes and wasteful delays are avoided.

At present the glowing ingots are dragged from the pits by tongs and



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carried to a blooming mill, each riding in an automatically controlled overgrown perambulator. There they are passed between steel rollers resembling washing machine wringers until they take the form of flat slabs or rectangular billets. During the process a billet measuring twenty-one inches to a side may be compressed into an 8 X 8 bar. As many as fifteen passes between the rollers, plus controlled cooling by water jets, bring the billets and blooms up to quality specifications.

The finishing mills take advantage of the latest techniques. Billets can be pressed into structural members resembling T's, U's, I's, Z's, L's, H's and other nonalphabetical shapes in the twinkling of an eye. A glowing slab creeps into one end of a quarter-mile-long continuous hot strip mill and comes screaming out of the other end, faster than a man can run, reduced to a few thousandths of an inch in thickness, trimmed, annealed and all ready to be tin-plated. Even the plating is done on the run in an electrolytic bath that carefully deposits more tin on the side of the plate that will form the inside of the can than it does on the one that will be outside. Heavier sheets are stamped into intricate shapes by mighty presses or, by a new process, are form-drawn much as a piece of paper can be curled by drawing it over the edge of a table.

From the above it might appear that all is rosy in the multi-billion dollar steel industry; the industry that this year can supply each American with about fifteen hundred pounds of this precious metal. On the contrary, steel is facing some tough problems. It is constantly searching for new sources of ore, coke and flux supply. It is whipping up better alloys that compete with plastics, aluminum and newer metals. And it has to cut corners and reduce costs, a difficult job because of the tremendous amounts invested in gigantic plants.

First and foremost is the supply problem. This country isn't the raw materials cornucopia it once was although its metals consumption has skyrocketed nearly two-thirds since 1940 and now equals that of all the rest of the world. Coal has to be screened of slate, washed and carefully blended before it is fit to be coked for blast furnace use. The fluorspar needed as flux for high-quality alloys is becoming difficult to obtain while the rich iron ores in the Mesabi Range near Lake Superior will last only a few more years.

The industry already has found how to use low-grade magnetic taconite ore by crushing it to powder and baking it into mud balls.* It is learning how to use nonmagnetic taconite, or jasper, of which there is an extremely large supply. It has purchased ore fields in Labrador, Venezuela and Liberia although it will be

* The process is known as beneficiation.



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some time before transport facilities to those out-of-the-way places are fully developed. It also is rationalizing production as much as is humanly possible, even though hand-operated blooming and finishing mills still exist side by side with the latest automatic factories.

Steel's achievements in the field of research also are outstanding. They have to be because of the squeeze on nickle,* chromium molybdenum and other alloying materials that has existed since the beginning of World War II. Although few people realize it, America is making extensive use of National Emergency (NE) steels that consume very small quantities of these materials. The older high-alloy steels go almost exclusively to the armed forces.

NE steels are being produced in sufficient quantity only because steel researchers discovered, a few years ago, that boron, the hard gray element present in boric acid and *20 Mule Team Borax*, could make alloying materials stretch. By dumping a wheelbarrowful of the stuff into a ladle holding one hundred fifty tons of molten steel, a workman can save almost two and a half tons of nickel, about three-quarters of a ton of chromium and nearly one-third of a ton of molybdenum.

* The full name for this metal is Kupfernickel—Old Nick's copper. German miners gave it that tag because they found it so hard to work in their primitive forges. Cobalt, another alloying material, is named after Kobold, a spiteful gnome miner.

Here's how the percentages of alloying metals in steel of a given toughness and hardenability can be reduced by adding boron:

| ALLOYING METAL | WITHOUT BORON | BORON ADDED |
|---|---|---|
| Nickel | 2.0 | .4 |
| Chromium | .9 | .4 |
| Molybdenum | .4 | .1 |

The new "needled" or "hopped up" steels are by no means perfect but they will do. More than half a million net tons of them were produced during the first nine months of 1952 although practically none was made prior to 1951. What is even nicer: no bottleneck can develop. More than ninety-five per cent of the world's supply of boron is located within the United States.

Up at the Massachusetts Institute of Technology these days the Department of Metallurgy is using some three million dollars worth of equipment to help the steel industry come up with other wonders like boron. The program makes use of the full-time work of more than two hundred graduate students, technicians, research fellows and professors and has an annual budget of nearly one million dollars.

The project employs machines that can measure impurities and alloying elements in metals to within .00001 of one per cent. (They look and sound like the gadget in Alec Guiness' film,



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"The Man in the White Suit.") Then there is a Tinker Toy phantasy that "draws" a three-dimensional diagram of the crystalline structure in an alloy.

Right now the Department is concentrating on methods to reduce unwanted sulfur in steel. Professor John Chipman, head of the center, and his co-worker, Professor Nicholas Grant, think that if aluminum chips or pellets were injected into slag through hot-air blowers near the bottom of a blast furnace, pig iron sulfur might take a nose dive. Another big project, conducted by Professor Herbert Uhlig, is trying to find ways to reduce the rust and other forms of corrosion that cost this country between five and six billion dollars a year. Uhlig thinks the answer may lie in the thin layer of mysterious oxide that forms on the surface of stainless steel and acts as a protective barrier against corrosion.

Research laboratories of various steel companies also are hard at work on new or better alloys, methods for recovering hard-to-get manganese and other products from slag, ways for substituting oxygen for air in furnace blasts, and similar production improvements. They know how to lick creep, that strange tendency to become distorted that steel displays in the presence of extremely high temperatures. They can make steam turbines that run for years at peak temperatures of well over 1,000° F. By means of fantastic pressures they can squirt hot or cold steel through dies like toothpaste from a tube. They have even developed a steel that will permit electricity to flow through it only along one prescribed path.

Yes, steel is sitting on top of the world. But it is sitting on a tack—a tack made either of aluminum, magnesium, titanium or plastic! Steel production is going up, certainly, but production of the newer metals and synthetics is rising much faster. By 1975 they are expected to reach about a third of steel's volume. And after that? Well, aluminum can be made from mud, magnesium and titanium from sea water, and plastics from sawdust or cornstalks. But there is only so much iron ore in the world until somebody finds a way of scraping the green slime called glauconite off the ocean's shores or convincing plankton that it should surrender the iron it concentrates from sea water.

Up to about 1900, men had worked only fourteen metals—copper, tin, zinc, iron, lead, gold, silver, mercury, antimony, arsenic, bismuth, nickel, manganese and cobalt. Since then, thirty others have come into commercial use while at least thirty-five others are being eyed as substitutes or improvers for the dwindling old timers.

The smaller companies that have sprung up to work the newcomers are intent on taking the play away from "big steel" and are going to be mighty hard to beat in the years ahead. To cite an example: International Nickel



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had found a way to by-pass the entire steel-making process. By adding a small amount of magnesium to brittle pig iron it has made a ductile iron which combines many of the best qualities of wrought iron and steel. Ductile iron is putting small foundries back in competition with the big fabricators. Production has jumped from nothing in 1949 to one hundred thousand tons last year. Its inventors predict it will hit five million tons in a few years and become America's third most important metal.

Right now, aluminum is America's *second* most important metal. By the end of this year it will be running nearly eight times above its 1940 production level and by 1955 should be two million four hundred thousand tons annually. Plants are going up all over; extrusion processes are being perfected; forge-tempered airplane wing spars can now be tapered from fifteen and one half inches on the fuselage end to ten inches at the tip, thus saving precious weight; electroplating processes make aluminum engine pistons as hard as steel on the surface; heat-treated, quenched and *refrigerated* aluminum rivets are competing with steel on construction projects because they can be driven cold, while aluminum curtain wall panels are *de rigeur* for this year's skyscrapers. Finally, don't ignore lightweight aluminum "invasion pipe." It can be transported by helicopter in twenty-foot lengths, dropped to the site of use and employed to supply a mobile army or air force with fuel, oil and water. In peacetime it can, with equal facility, help farmers fight a drought.

Magnesium? Well, it's expected to reach an annual production rate of one hundred thirty thousand tons this year. It is the lightest of structural metals but it has a bad tendency to corrode in salt air or under stress. Much more work is needed on this metal, particularly in view of the fact that the supply is inexhaustible and that it weighs one-third less than aluminum. Chief source for magnesium is a compound recovered from sea water by the use of lime. This compound is then converted to magnesium chloride with hydrochloric acid. In eighty-five per cent concentration, it is electrolyzed in a fused bath to give the pure metal. Eight kilowatt-hours of electricity are needed to make one pound of magnesium metal.

While licking the magnesium bugs, metallurgists also are turning their attention to those willful sisters, titanium and zirconium. Titanium is coming up in a great hurry—from nothing in 1951 to twelve hundred tons last year. By 1955 it is expected to reach twenty-two thousand tons. It is almost ideal for construction of fast naval vessels, light ordnance, jet planes and spaceships. It combines strength with light weight, has a very high melting point and resists



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corrosion except under one condition.

But disgusted engineers and workmen who struggle to separate ductile titanium from ilmenite and rutile-ore sands in vacuum-arc furnaces under inert helium atmospheres call it the strumpet metal: It combines with anything when hot! That is why it still is very expensive and why it has not fulfilled its early promise of making perfect rotor blades for jet turbines working at 2,000° F.

Much the same difficulty is encountered in dragging zirconium from its ores. Zirconium is much in demand by the Atomic Energy Commission because it combines excellent corrosion resistance with high permeability to slow neutrons. This metal is as strong as steel but, like titanium, weighs only two-thirds as much. It is widely available. Its orthosilicate is a diamondlike jewel called a zircon. But, in its raw state, it clings madly to hafnium and groans audibly when efforts are made to separate the two. And since hafnium readily absorbs neutrons, it counteracts many of the useful characteristics of its twin.

So far, refining has been done by the batch, either in an atmosphere of inert gas or in a high vacuum. Until very recently the only prospect for producing it in bulk seemed to be to set up a refinery on the airless moon. Now, one company believes it has developed a system to obtain titanium and zirconium compounds by electrolysis. Another concern reports continuous refining, using the Kroll process that feeds liquid zirconium—or titanium—tetrachloride into a vessel half-full of boiling magnesium.

The latter method works like this: Zirconium ore mined in Florida is upgraded or beneficiated to a carbide. This is chlorinated to a tetrachloride. At this point a secret AEC treatment removes the hafnium and produces an oxide. The latter is mixed with carbon black and a binder and briquetted, turned back into a tetrachloride and doused in the boiling magnesium. For every pound of magnesium used, one pound of pure zirconium metal is produced.

The work on titanium and zirconium has disclosed that a mere fraction of one per cent of impurities can change the properties of rarer metals almost beyond recognition. Several companies now are endeavoring to produce ultra-pure hafnium, lithian, columbium, et cetera, on the theory that they may provide metallurgical miracles. Others are working with the so-called rare earths—which aren't rare at all but *are* found in widely-dispersed form.

There's germanium, for instance. It can be recovered from ordinary chimney smoke. In the form of transistor crystals it bids fair to revolutionize the electronics business. If those tiny transistors can be made cheaply in bulk, and *if* a way is found to stabilize their characteristics and reduce the number of rejects, radio



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sets can be as small as wrist watches while TV receivers may be carried in a coat pocket.

Lithium, the lightest metal known; the plentiful silicones that among their almost unknown characteristics make lubricants that work equally well at 100° above or 100° below zero F.; uranium, that can produce power to compete with coal selling at two cents a ton; the ceramic-to-metal—cermet—bonds that stand up in the hottest jet turbines—it would be impossible to even list all of them.

There are even more of the versatile hydrocarbon compounds. Hundreds of thousands are known to exist. A few hundred have been isolated in the laboratory. A tithe of that number have been manufactured in commercial quantities. Yet the number of commercial solvents, types of synthetic rubber and varieties of plastics, paints, fertilizers, fabrics, insecticides —and even perfumes—that can be made from the few "domesticated" mixtures of hydrogen and carbon run into the thousands. The United States petrochemical output has grown from a puny four billion pounds in 1940 to seventeen billion pounds this year and is expected to hit sixty-eight billion or so by 1963. Practically all of it comes from crude oil, natural gas or coal.

It might look to the layman as if the human race could sit and relax for a time once more, while the social sciences catch up with the achievements of physics, chemistry and engineering. But those who have studied the situation most—people like Hugh Bennett, William Voigt, Louis Bromfield, Henry Fairfield Osborn, Milton Eisenhower and William S. Paley, to name just a handful—are uneasy. True, they see a period of prosperity and plenty lasting until about 1975. Then, if we haven't blown ourselves up with A, H, or Z bombs, they suggest we'll have to hustle out and begin looking for substitutes for substitutes! Many raw materials that are just coming into use today will be close to exhaustion within a quarter century and some of the old standbys may have become museum pieces.

What will the world be like one hundred years or so ahead if we keep chewing up metals, chemicals, soil, water and so on at the present ever-increasing rate? Volume IV of the fascinating 1952 report by the President's Materials Policy Commission attempts to give a partial answer to that question. First, it warns that the United States will have become an importer of tremendous quantities of all kinds of goods. Then, it adds, the nation will be depending more and more upon its non-wasting assets such as farm, forest and marine products; solar, hydroelectric and tidal power and such virtually inexhaustible metals as silicon and magnesium.

As the years pass it is logical to assume that steel will be made from



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lower grade ores with higher and higher percentages of scrap added. (Allowing a can to rust may become a serious crime, both because of the loss of tin and steel.) Perhaps some way eventually may be found to collect the iron-bearing sludge and nodules on the ocean bottom. If not, steel may find itself faced with the toughest kind of competition with newer materials.

The report forecasts that domestic production of petroleum will start to decline in the 1960s. Eventually, it thinks, crude oil may be conserved for use in petrochemicals and fine lubricants while liquid fuels are synthesized from our tremendous supplies of shale, tar sands and low grade coal. Or the coal may be burned right in the ground to produce gas that can be liquefied under pressure.

Atomic fission may provide about a fifth of the world's power until the uranium runs out a century or so hence. Then, unless the fusion of hydrogen has become practicable, more and more dependence will be placed on sun power, tidal power and warmth obtained from the earth itself by means of heat pumps.

Land and sea will be farmed with equal intensity, particularly if the world's population keeps climbing at the present rate. Eroded soil will be rebuilt with synthetic resin conditioners and with synthetic ammonium nitrate and sulfate fertilizers made from oil and coal. The weather will be at least partially controlled to get the greatest benefit out of rainfall, delay frosts, et cetera.

Forests will be allowed to grow only the most useful varieties of trees while chips, bark, sawdust and roots will be made into chemicals, plywoods or food.

Magnesium, vanadium, salt and hundreds of other materials will be extracted from sea water. The fresh water obtained in the process is almost certain to be used in vast irrigation projects. Such projects are becoming vital even now because of the steady drop in the underground water table all over the world.

Fishing and the collection of kelp and other sea foods certainly will not be done on the present wasteful hit-or-miss basis. The PMPC report thinks the sea itself may be fertilized.

But the greatest visible change in the world of the not-so-distant future may be its use of glass and other silicon products to make everything from fabrics to highways; to replace many structural metals and to coat those that remain so they can resist corrosion indefinitely. Such products will remain as plentiful as the sands of the sea. They may well provide the substitutes to end all substitutes, the shining ones that, in the end, will make it forever unnecessary for mankind to creep back into the cave in search of warmth and shelter.

THE END



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# THE ANALYTICAL LABORATORY

Evidently we're going over to the Leedham 10-point scoring system; a very large percentage of the readers used it in reporting on the April issue, and the May issue reports just beginning to come in also show a strong liking for it. I myself feel it's a valid system. But since it's you folks who have to take the trouble to use it, it's for you to say whether it is used or not. The answer looks like "Yes!"

My thanks—and the thanks of the authors—are due you also for the very large increase in the votes beginning with the April issue. Since this department is now not only the box score, but also the box office, the authors are most naturally interested in a real vote; you determine what the author gets for his yarn.

For newcomers: The magazine pays a normal 3¢ a word rate for stories. Yarns I think exceptionally good I'll pay 4¢ on. But if I underrate a story, and the reader-vote shows it earned the bonus . . . my error, and the author gets an extra check. (If I paid on one that you readers didn't think earned it, the author doesn't have to pay back the bonus, just to settle that question! But it'll encourage me to make better predictions of reader response!)

So . . . here's the score on the April issue.

| *Place* | *Story* | *Author* | *Points* |
|---|---|---|---|
| 1. | MISSION OF GRAVITY (I) | *Hal Clement* | 1.89 |
| 2. | THE ANT AND THE EYE | *Chad Oliver* | 2.61 |
| 3. | FAMILY RESEMBLANCE | *Alan E. Nourse* | 3.06 |
| 4. | SETTLE TO ONE | *Charles Dye and April Smith* | 3.26 |
| 5. | ALLEGORY | *W. T. Powers* | 3.57 |

Hal Clement earned the bonus on Part I of "Mission of Gravity."

Incidentally, I'm not going to indicate what stories I've paid a bonus on before publication; I want your opinions. The fact that a story is illustrated on the cover doesn't prove I thought it would take first place; it proves I thought it had the best cover-illustration possibilities of any story in that issue. Some stories concern things that simply can't be illustrated as a cover, no matter how good the story is.

THE EDITOR.



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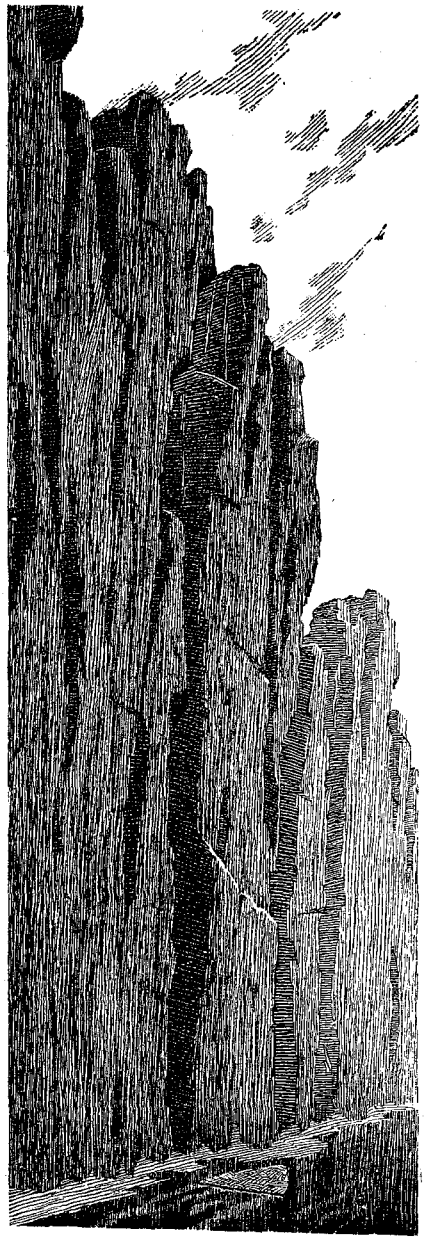
# MISSION OF GRAVITY

## BY HAL CLEMENT

***Conclusion.*** *Under the violent grip of seven hundred gravities, at the south polar plateau, with the goal in sight — Barlennan was in position to drive a bargain!*

Illustrated by van Dongen



### SYNOPSIS

*For the first time in history, the scientists of Earth and the planets of nearby stars have acquired the opportunity to make studies of a really intense gravitational field. The solitary planet of the brighter component of the binary star 61 Cygni has a mass some five thousand times that of Earth, but because it consists largely of degenerate matter has a volume not much larger*



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*than that of Uranus. Ordinarily this would mean a surface gravity of about three hundred times that of Earth, and for several similar worlds this has been the case; but the 61 Cygni planet has such an enormously rapid rotation rate that, while its effective equatorial gravity is only three times that of Earth, the extreme flattening gives it well over six hundred G's at the poles.*

*Recognizing the opportunity, the governments of several planets pool resources and construct a special research rocket which will be capable of landing in those polar regions without destruction, and load it with as much varied apparatus as their scientists can devise. Under remote control, the rocket lands at the south pole of the giant planet, presumably secures its data—but fails to respond to the take-off signal. Some of the data was telemetered, but some is on records that must be physically recovered; and no known living creature can survive in the gravity of the polar regions.*

*However, a station is built at the equator to do what can be done; and Charles Lackland, while conducting xenological investigations near the dome, encounters Barlennan, a native of the world, which he calls Mesklin.*

*Barlennan is the captain and owner of a tramp ship, half trader and, Lackland suspects, half pirate, exploring the almost unknown equatorial zone of the world. He has beached his ship, the* Bree, *near the station for the season; Mesklin is approaching periastron, which is also the northern hemisphere's midsummer, and the boiling of the cap of frozen methane which has built up around the northern pole during the preceding four Earth-years creates tremendous storms which render the seas impassable. Lackland and Barlennan form a friendship, partly because each sees a chance of obtaining what he wants from the other and partly because of natural sympathy. The Mesklinite, over a period of several weeks, learns a great deal of Lackland's language, and a tentative agreement is reached whereby Barlennan is to make the thirty-thousand-mile voyage to the south pole, find the grounded rocket, and transmit its information by a specially designed radio-television unit which the scientists of the expedition devise to withstand Mesklin's cold, pressure, and gravity—it is a solid block of material, using only printed circuits, transistors, and similar non-living parts. In return the expedition is to furnish weather predictions for Barlennan until he returns to his own country, thus enabling him to carry safely a far larger cargo.*

*The trip cannot be started until the beginning of spring in the southern hemisphere, and in the interval it is discovered through the examination of photographs made from space that the downed rocket is very awkwardly located—an overland journey of several thousand miles will be needed for the* Bree's *crew to reach it. Another body of "water" also reaches the south polar regions, and a river feeding it passes within a few*



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*miles of their goal; but no navigable passage to this second sea can be found on the photographs. However, an incident which occurs when Lackland and Barlennan are exploring some miles from the station gives the latter an idea. The tank in which they were riding is crippled, and the Earthman's cumbersome armor makes it impossible for him to reach the dome in the triple gravity; but the crew of the* Bree *is able to tow him back on a sled made of metal from the wrecked tank. Barlennan now suggests that a similar sled be made for his ship, and towed to the other ocean by another tank.*

*This proves feasible, as the ocean extends into the low-gravity regions of the equator where Lackland can survive to operate the tank. The route is laid out with the aid of more aerial photographs, the sled constructed at the main expedition base on Toorey, Mesklin's inner moon, and ferried to the equatorial station. As winter draws to a close, the* Bree *is loaded aboard—the ship is only forty feet in length, and easily carried by her crew in their present near-weightless environment—and the trip starts.*

*Barlennan, through a misunderstanding of Lackland's, has already had an experience which has jarred out of him the ingrained, conditioned fear of height characteristic of all natives of his part of the planet—a fear amply justified by the savage gravitation under which they live, which makes a fall of even half their eighteen-inch body length almost certainly fatal. The very idea of a fall is strange to them; in their land, an object released at a height simply disappears, to reappear almost simultaneously on the ground below in a well flattened state.*

*During the journey the crew is also forced to defy this conditioning; while trading in a strange city discovered en route, they are attacked by the natives, whose method of assault consists of rolling large rocks from the hill completely encircling the town. The only escape for the Mesklinites is by jumping or climbing to the tank's roof; the vehicle itself is saved by destroying with high-explosive shells the only rock in a position to do it serious damage. After this, the Mesklinites become almost comically defiant of their old fears, jumping and climbing with what amounts to recklessness and causes Barlennan some concern.*

*The journey is continued, and is almost at its end when the tank encounters an apparently insuperable obstacle—a cliff some sixty feet in height dropping away ahead of them, and extending as far as can be seen in either direction. The tank cannot possibly negotiate such a drop; and even in the relatively feeble gravity of the equatorial zone sixty feet is too much for the Mesklinites—and for their ship.*

*Further aerial reconnaissance indicates that the cliff extends much too far in both directions to be rounded, but that two rivers empty over its edge within reasonable distance of the tank's present position. The travelers proceed to one of these and, again at Barlennan's sug-*



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*gestion, the* Bree *is disassembled and hoisted over the edge, together with her crew. The ship is quickly put together again by the river at the cliff's foot, and launched. She proceeds on her way alone, while Lackland, who has done all he could on Mesklin's surface, calls the rocket to take him back to Toorey.*

*On the way downstream, Barlennan encounters savages of his own species and for the first time in his life sees a canoe. He is deeply impressed with the load-carrying powers of this strange, hollow boat—the* Bree *is a collection of rafts bound together to combine strength with flexibility—and acquires one, dreaming of revolutionizing the maritime commerce of his nation.*

*Eventually he reaches the ocean and heads south, guided and aided by weather reports and predictions from above. In sheltering from a storm in a group of islands near the seven-gravity latitude, the crew encounters another nation of their own species which has mastered flight, to the intense surprise of the watching scientists; Mesklin's intense gravity and hydrogen atmosphere had made such a feat on the part of the semi-civilized natives seem unlikely at the very least. Barlennan learns much, although the islands guard fiercely the secrets of their gliders from the "barbarian" visitors. He learns, for example, of missile weapons, which are quite impossible at his two-hundred-gravity home latitude; the islanders drop spears from their gliders, and also use crossbows. The* Bree *escapes with some difficulty after an official of the islanders becomes convinced that the* Bree's *crew is deliberately spying. Resuming his southward journey, Barlennan learns why canoes are not used by his people; the increasing gravity causes a corresponding increase in pressure below the ocean surface, and the canoe towing behind the ship is crushed. Barlennan is almost equally so some time later, when the* Bree, *after reaching the southern end of the ocean and ascending the river to the point indicated by the photographs and radio fixes as being closest to the grounded rocket, finds herself at the foot of another cliff. This one is a full three hundred feet in height; and three hundred feet in Mesklin's polar gravity corresponds to a* vertical *distance, on Earth, of some thirty-five miles. The rocket is somewhere beyond the top of the cliff.*

## XV.

The change of mind that had so affected the *Bree's* crew was not temporary; the unreasoning, conditioned fear of height that had grown with them from birth was gone. They still, however, had normal reasoning power; and in this part of their planet a fall of as much as half a body's length was nearly certain to be fatal even to their tough organisms. Changed as they were, most of them felt uneasy as they moored the *Bree* to the river bank only a few rods from the towering cliff that barred



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them from the grounded rocket.

The Earthmen, watching in silence, tried futilely to think of a way up the barrier. No rocket that the expedition possessed could have lifted itself against even a fraction of Mesklin's polar gravity; the only one that had ever been built able to do so was already aground on the planet. Even had the craft been capable, no human or qualified nonhuman pilot could have lived in the neighborhood; the only beings able to do that could no more be taught to fly a rocket than a Bushman snatched straight from the jungle. Two or three generations of education could no doubt produce Mesklinites fit for the task; but that would be much too long to wait.

"The journey simply isn't as nearly over as we thought." Rosten, called to the screen room, analyzed the situation rapidly. "There should be some way to the plateau or farther slope — whichever is present — of that cliff. I'll admit there seems to be no way Barlennan and his people can get *up;* but there seems to be nothing preventing their going around." Lackland relayed this suggestion to the captain.

"That is true," the Mesklinite replied. "There are, however, a number of difficulties. It is already getting harder to procure food from the river; we are very far from the sea. Also, we have no longer any idea of how far we may have to travel, and that makes planning for food and all other considerations nearly impossible. Have you prepared, or can you prepare, maps with sufficient detail to let us plan our course intelligently?"

"Good point. I'll see what can be done." Lackland turned from the microphone to encounter several worried frowns. "What's the matter? Can't we make a photographic map as we did of the equatorial regions?"

"Certainly," Rosten replied. "A map can be made, possibly with a lot of detail; but it's going to be difficult. At the equator a rocket could hold above a given point, at circular velocity, only six hundred miles from the surface — right at the inner edge of the ring. Here circular velocity won't be enough, even if we could use it conveniently; even a parabolic path would intersect the surface of the planet, since the world's curvature is so small in the polar regions. We'd have to use a hyperbolic orbit of some sort to get short-range pictures without impossible fuel consumption; and that would mean speeds relative to the surface of several hundred miles a second. You can see what sort of pictures that would mean. It looks as though the shots will have to be taken with long-focus lenses, at extremely long range; and we can only hope that the detail will suffice for Barlennan's needs."

"I hadn't thought of that," admitted Lackland. "We can do it, though; and I don't see any alternative in any case. I suppose Barlennan



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could explore blind, but it would be asking a lot of him."

"Right. We'll launch one of the rockets and get to work. We can rig some of the astronomical lenses with film holders that already have focal-plane shutters; that should give scale enough." Lackland gave the substance of this conversation to Barlennan, who replied that he would stay where he was until the information he needed was obtained.

"I could either go on upstream, following the cliff around to the right, or leave the ship and the river and follow to the left. Since I don't know which is best from the point of view of distance, we'll wait. I'd rather go upstream, of course; carrying food and radios will be no joke otherwise."

"All right. How is your food situation? You said something about its being hard to get that far from the ocean."

"It's scarcer, but the place is no desert. We'll get along for a time at least. If we ever have to go overland, we may miss you and your gun, though. This crossbow has been nothing but a museum piece for nine tenths of the trip."

"Why do you keep the bow?"

"For just that reason — it's a good museum piece, and museums pay good prices. No one at home has ever seen, or as far as I know even dreamed of, a weapon that works by throwing things. You couldn't spare one of your guns, could you? It needn't work, for that purpose." Lackland laughed.

"I'm afraid not; we have only one. We don't expect to need it, but I don't see how we could explain giving it away."

Barlennan gave the equivalent of an understanding nod, and turned back to his own duties. He had much to bring up to date on the bowl that was his equivalent of a globe; the Earthmen, throughout the trip, had been giving him bearing and distance to land in all directions, so he was able to get most of the shores of the two seas he had crossed onto the concave map.

It was also necessary to see to the food question; it was not, as he had told Lackland, really pressing, but more work with the nets was going to be necessary from now on. The river itself, now about two hundred yards wide, appeared to contain fish enough for their present needs, but the land was much less promising. Stony and bare, it ran a few yards from one bank of the stream to end abruptly against the foot of the cliff; from the other, a series of low hills succeeded each other for mile after mile, presumably far beyond the distant horizon. The wind came steadily around the cliff from the left.

The cliff itself seemed to have been pushed up bodily from below by the cataclysmic natural forces always at work in Mesklin's interior, where



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pressures existed sufficient to keep a good part of the planet's mass in the degenerate, enormously dense state characteristic of white dwarf stars. The rock of the escarpment's face was polished glass-smooth, as sometimes happens even on Earth to the rocks at the sliding edges of a fault. Climbing it, even on Earth, would have required the equipment and body weight of a fly — on Mesklin, the fly would have weighed too much. Vegetation was present, but not in any great amount, and in the first fifty days of their stay no member of the *Bree's* crew saw any trace of land animal life. Occasionally someone thought he saw motion, but each time it turned out to be shadows cast by the whirling sun, now hidden from them only by its periodic trips beyond the cliff. They were so near the south pole that there was no visible change in the sun's altitude during the day.

It might easily have been possible for hunting parties to become lost, except for the presence of the towering wall of stone that held them here. As a landmark it was ideal, or almost so; it would be visible from any hilltop for many miles, until it merged with the rising horizon — certainly much farther than any hunters would go; the only trouble would be the impossibility of determining from a distance just what part of the level cliff top was above the *Bree's* position. That, however, could also be solved; parties could go out bearing either definitely right or definitely left of the line straight away from the barrier. Then if they returned straight toward it, they would know whether they struck the river upstream or down from the desired point. Barlennan made sure this was understood by the entire crew before he allowed anyone to explore. Then, food more or less assured and examination of the neighborhood well under way, he settled down to wait.

For the Earthmen, the time was a little more active. Four of the expedition, including Lackland, manned the rocket and dropped planetward from the rapidly moving moon. From their take-off point the world looked rather like a pie plate with a slight bulge in the center; the ring was simply a line of light, but it stood out against the background of star-studded blackness and exaggerated the flattening of the giant world.

As power was applied both to kill the moon's orbital velocity and bring them out of Mesklin's equatorial plane the picture changed. The ring showed for what it was, but even the fact that it also had two divisions did not make the system resemble that of Saturn. Mesklin's flattening was far too great for it to resemble anything but itself — a polar diameter of less than twenty thousand miles compared to an equatorial one of some forty-eight thousand has to be seen to be appreciated. All the expedition mem-



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bers had seen it often enough now, but they still found it fascinating.

The fall from the satellite's orbit gave the rocket a very high velocity, but, as Rosten had said, it was not high enough. Power had to be used in addition; and although the actual pass across the pole was made some thousands of miles above the surface, it was still necessary for the photographer to work rapidly. He was using a very narrow angle lens, and took several exposures on each pass; but correlating them was still going to be a job.

Three runs were actually made, each taking between two and three minutes for the actual photography and many more for the whipping journey around the planet. They made reasonably sure that the world was presenting a different face to the sun each time, so that the height of the cliff could be checked by shadow measurements on all sides; then, with the photographs already fixed and on one of the chart tables, the rocket spent more fuel swinging its hyperbola into a wide arc that intercepted Toorey, and killing speed so that too much acceleration would not be needed when they got there. They could afford the extra time consumed by such a maneuver; the mapping could proceed during the journey.

Results, as usual with things Mesklinite, were interesting if somewhat surprising. In this case, the surprising fact was the size of the fragment of planetary crust that seemed to have been thrust upward en bloc. It was shaped rather like Greenland, some thirty-five hundred miles in length, with the point aimed almost at the sea from which the *Bree* had come. The river leading to it, however, looped widely around and actually contacted its edge at almost the opposite end, in the middle of the broad end of the wedge. Its height at the edges was incredibly uniform; shadow measurements suggested that it might be a trifle higher at the point end than at the *Bree's* present position, but only slightly. There were no sawtooth shadows to indicate gaps in the wall.

Except at one point. One picture, and one only, showed a blurring of the shadow that might be a gentler slope. It was also in the broad end of the wedge, perhaps eight hundred miles from where the ship now was. Still better, it was upstream — and the river continued to hug the base of the cliff. It looped outward at the point where the shadow break existed as though detouring around the rubble pile of a collapsed slope, which was very promising indeed. It meant that Barlennan had sixteen or seventeen hundred miles to go instead of fifty, with half of it overland; but even the overland part should not be overwhelmingly difficult. Lackland said so, and was answered with the suggestion that he make a more careful analysis of the surface over which



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his small friend would have to travel. This, however, he put off until after the landing, since there were better facilities at the base.

Once there, microscopes and densitometers in the hands of professional cartographers were a little less encouraging, for the plateau itself seemed rather rough. There was no evidence of rivers or any other specific cause for the break in the wall that Lackland had detected; but the break itself was amply confirmed. It was apparently a cleft, narrower than Lackland had thought, leading from the inner plateau to the base; and at its foot there was, as expected, a pile of detritus that had diverted the river on which the *Bree* had traveled.

The pile itself should have been the product of a river, like the cleft from which its material had presumably come; but no evidence of such a stream could be found. Furthermore, there was no sign of liquid anywhere on the plateau, and no certain evidence of life in any form. The densitometer indicated that the center of the region was lower than the rim, so that it was actually a gigantic shallow bowl; but its depth could not be determined accurately, since there were no distinct shadows across the inner portion. The analysts were quite sure, however, that its deepest part was still well above the terrain beyond the cliffs.

Rosten looked over the final results of the work, and sniffed.

"I'm afraid that's the best we can do for him," he said at last. "Personally, I wouldn't have that country on a bet even if I could live in it. Charlie, you may have to figure out some way to give moral support; I don't see how anyone can give physical."

"I've been doing my best all along. It's a nuisance having this crop up when we were so close to home plate. I just hope he doesn't give us up as a bad job this close to the end; he still doesn't believe everything we say, you know. I wish someone could explain that high-horizon illusion to his — and my — satisfaction; that might shake him out of the notion that his world is a bowl, and our claim to come from another is at least fifty per cent superstition on our part."

"You mean you don't understand why it looks higher?" one of the meteorologists exclaimed in a shocked tone.

"Not in detail, though I realize the air density has something to do with it."

"But it's simple enough —"

"Not for me."

"It's simple for anyone. You know how the layer of hot air just above a road on a sunny day bends sky light back upward at a slight angle, since the hot air is less dense and the light travels faster in it; you see the sky reflection and tend to interpret it as water. You get more extensive



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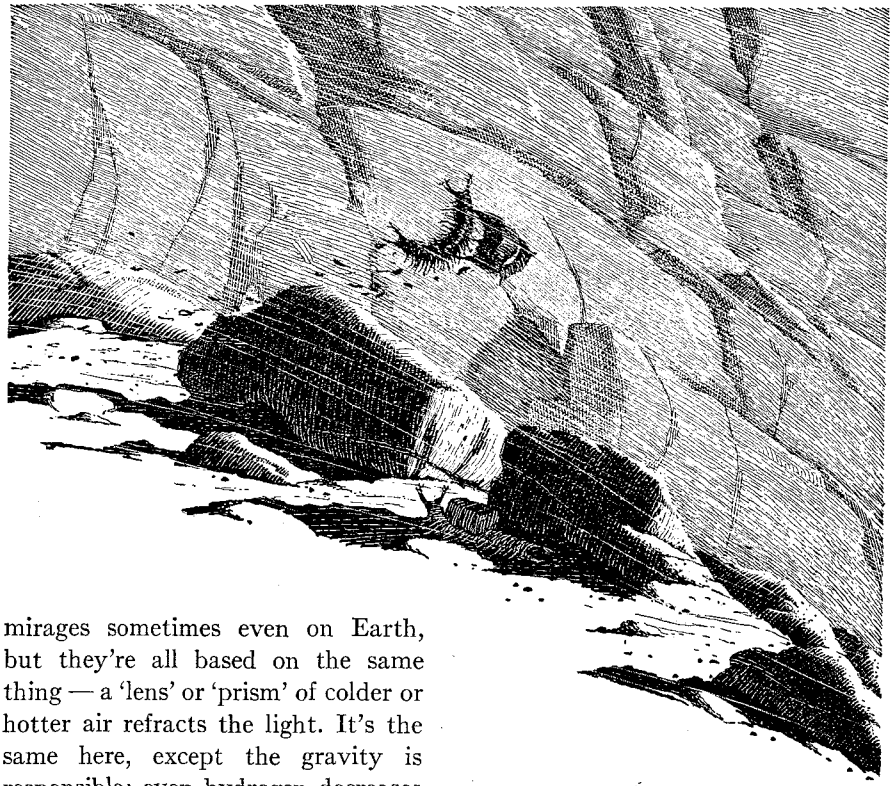

mirages sometimes even on Earth, but they're all based on the same thing — a 'lens' or 'prism' of colder or hotter air refracts the light. It's the same here, except the gravity is responsible; even hydrogen decreases rapidly in density as you go up from Mesklin's surface. The low temperature helps, of course."

"All right if you say so; I'm not a —" Lackland got no chance to finish his remark; Rosten cut in abruptly and grimly.

"Just how fast does this density drop off with altitude?" The meteorologist drew a slide rule from his pocket and manipulated it silently for a moment.

"Very roughly, assuming a mean temperature of minus one sixty, it would drop to about one per cent of its surface density at around fifteen or sixteen hundred feet." A general stunned silence followed his words.

"And . . . how far would it have dropped at . . . say . . . *three hundred feet?*" Rosten finally managed to get the question out. The answer came after a moment of silent lip movement.

"Again very roughly, seventy or eighty per cent — probably rather more."



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Rosten drummed his fingers on the table for a minute or two, his eyes following their motions; then he looked around at the other faces. All were looking back at him silently.

"I suppose no one can suggest a bright way out of this one; or does someone really hope that Barlennan's people can live and work under an air pressure that compares to their normal one about as that at forty or fifty thousand feet does to ours?"

"Maybe he doesn't use the air as we —" someone began.

"Of course he doesn't; he reduces unsaturated hydrocarbons with free hydrogen. He still needs a certain minimum concentration of hydrogen to keep him supplied, and probably a minimum pressure to get it into his tissues. I'll bet a large sum that it's not far below the concentration and pressure he gets in his regular atmosphere. How about it, Charlie? You're no biologist, but you know Barlennan."

"I'm not sure." Lackland frowned in concentration, and Rosten brightened a trifle. "There was some reference a long time ago to his staying under water — excuse me, under methane — for quite a while, and swimming considerable distances. You remember those river dwellers must have moved the *Bree* by doing just that. If it's the equivalent of holding breath or a storage system such as our whales use, it won't do us any good; but if he can actually get a fair part of the hydrogen he needs from what's in solution in Mesklin's rivers and seas, there might be some hope." Rosten thought for a moment longer.

"All right. Get your little friend on the radio and find out all he knows himself about this ability of his. Rick, look up or find out somehow the solubility of hydrogen in methane at eight atmospheres pressure and temperatures between minus one forty-five and one eighty-five Centigrade. Dave, put that slide rule back in your pocket and get to a calculator; get as precise a value of the hydrogen density on that clifftop as physics, chemistry, math, and the gods of good weathermen will let you. Incidentally, didn't you say there was a drop of as much as three atmospheres in the center of some of those tropical hurricanes? Charlie, find out from Barlennan whether and how much he and his men felt that. Let's go."

The conference broke up, its members scattering to their various tasks. Rosten remained in the screen room with Lackland, listening to his conversation with the Mesklinite far below.

Barlennan agreed that he could swim below the surface for long periods without trouble; but he had no idea how he did it. He did not breathe anyway, and did not experience any feeling comparable to the human sense of strangulation when he



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submerged. If he stayed too long and was too active, the effect was rather similar to sleepiness, as nearly as he could describe it; if he actually lost consciousness, however, it stopped there; he could be pulled out and revived as much later as anyone cared as long as he didn't starve in the meantime. Evidently there was enough hydrogen in solution in Mesklin's seas to keep him alive, but not for normal activity. Rosten brightened visibly.

"There is no discomfort of the sort you suggest in the middle of worst storms I have ever experienced," the captain went on. "Certainly no one was too weak to hold on during that one which cast us on the island of the gliders — though we were in its center for only two or three minutes, of course. What is your trouble? I do not understand what all these questions are leading to."

Lackland looked to his chief for permission, and received a silent nod of affirmation.

"We have found that the air on top of this cliff, where our rocket is standing, is very much thinner than at the bottom. We doubt seriously that it will be dense enough to keep you and your people going."

"But that is only three hundred feet; why should it change that much in such a short distance?"

"It's that gravity of yours; I'm afraid it would take too long to explain why, but on any world the air gets thinner as you go higher, and the more the gravity the faster that change. On your world the conditions are a trifle extreme."

"But where is the air at what you would call normal for this world?"

"We assume at sea level; all our measures are usually made from that reference." Barlennan was thoughtful for a little while.

"That seems silly; I should think you'd want a level that stayed put to measure from. Our seas go up and down hundreds of feet each year — and I've never noticed any particular change in the air."

"I don't suppose you would, for several reasons; the principal one is that you would be at sea level as long as you were aboard the *Bree*, and therefore at the bottom of the atmosphere in any case. Perhaps it would help you to think of this as a question of what weight of air is above you and what weight below."

"Then there is still a catch," the captain replied. "Our cities do not follow the seas down; they are usually on the seacoast in spring and anywhere from two hundred miles to two thousand inland by fall. The slope of the land is very gentle, of course, but I am sure they are fully three hundred feet above sea level at that time."

Lackland and Rosten stared silently at each other for a moment; then the latter spoke.

"But you're a lot farther from the



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pole in your country . . . but no, that's quibbling. Even if gravity were only a third as great you'd be experiencing tremendous pressure changes. Maybe we've been taking nova precautions for a red dwarf." He paused for a moment, but the Mesklinite made no answer. "Would you be willing, then, Barlennan to make at least an attempt to get up to the plateau? We certainly will not insist on your going on if it proves too hard on your physical make-up, but you already know its importance to us."

"Of course I will; we've come this far, and have no real reason to suppose what's coming will be any worse than what's past. Also, I want —" he paused briefly, and went on in another vein. "Have you yet found any way of getting up there, or is your question still hypothetical?" Lackland resumed the human end of the conversation.

"We have found what looks like a way, about eight hundred miles upstream from your present position. We can't be sure you can climb it; it resembles a rock wall of very moderate slope, but we can't tell from our distance how big the rocks may be. If you can't get up there, though, I'm afraid you just can't get up at all. The cliff seems to be vertical all around the plateau except for that one point."

"Very well, we will head upstream. I don't like the idea of climbing even small rocks here, but we'll do our best. Perhaps you will be able to give suggestions when you can see the way through the vision sets."

"It will take you a long time to get there, I'm afraid."

"Not too long; for some reason there is a wind along the cliff in the direction we wish to go. It has not changed in direction or strength since we arrived several score days ago. It is not as strong as the usual sea wind, but it will certainly pull the *Bree* against the current — if the river does not grow too much swifter. They often do, of course, in their upper reaches."

"This one does not grow too much narrower, at any rate, as far as you will be going. If it speeds up, it must be because it grows shallower. All we can say to that is that there was no sign of rapids on any of the pictures."

"Very well, Charles. We will start when the hunting parties are all in."

"Have they found anything on land yet?"

"A few small animals have been netted, and some of the vegetation had edible fruit or leaves. Our main source of food is the river, though."

"Any people — villages, cities, or such like?"

"Not even lone wanderers. There were places in the plant groves where there should have been traces if anyone at all was around, but nothing of the sort was seen. The place could support people, but doesn't seem to."

"All right. I was just wondering for the sake of my ethnological friend.



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He's rather disappointed, I think, that you still have three vision sets in your possession."

"I'm rather surprised that we have after those glider makers. I was expecting that Reejaaren to confiscate the lot as a fine if one of you had spoken while he was aboard."

"I'm sure you could have talked him down to one. I'm surprised you didn't take one of their gliders with you when you left."

"I wanted to, but there really wasn't room on the ship." The conversation ended on that note, and Barlennan prepared to resume his upstream journey.

One by one the parties came back to the ship, all with some food but none with anything interesting to report. The rolling country extended as far in all directions as anyone had gone; animals were small, streams scarce, and vegetation sparse except around the few springs. Morale was a trifle low, but it improved with the news that the *Bree* was about to travel again. The few articles of equipment that had been disembarked were quickly reloaded on the rafts, and the ship pushed out into the stream. For a moment she drifted seaward, while the sails were being set; then they filled with the strangely steady wind and she bore up against the current, forging slowly but steadily into unknown areas of the hugest planet man had yet attempted to explore.

## XVI.

Barlennan rather expected the river banks to become more barren as his ship ascended the stream, but if anything, the reverse was the case. Clumps of sprawling, octopuslike growths hugged the ground at either bank, except where the cliff on his left crowded the river too closely to leave them room. After the first hundred miles from the point where they had waited several streams were seen emptying into the main course; and a number of the crewmen swore they saw animals slinking among the plants. The captain was tempted to land a hunting party and await its return, but two considerations decided him against it.

One was the wind, which still blew steadily the way he wanted to go; the other was his desire to reach the end of the journey and examine the miraculous machine the Flyers had set down and lost on the polar wastes of his world. What he could learn from that device would make him superior to the canoe-makers and glider-builders of the tropics, as well as the more conventional races of the middle latitudes.

As he had said, he could do just about as he pleased, and not a living creature on Mesklin would have the ability to deny him. To do him justice, he had no desire to embark on the career of a super-criminal; what he craved more was the adulation of



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the other members of his race. In spite of their weird outer forms and weirder body chemistry, the Mesklinites, as Lackland had said more than once, were amazingly human.

As the journey progressed, the captain grew more and more astonished at the wind; he had never before known it to blow steadily for more than a couple of hundred days in any direction. Now it was not merely maintaining direction but was turning to follow the curve of the cliff, so that it was always practically dead astern. He did not actually let the watch on deck relax completely, but he did not object when a man turned his attention away from his section of rigging for a day or so. He himself had lost count of the number of days since it had been necessary to trim sails.

Several conversations with the human meteorologists failed to cast light on the matter; they agreed, one and all, that any wind on Mesklin should be diverted so rapidly from its original course by the planet's enormous rate of spin as to form a cyclonic cell almost at once. This was, in fact, the first place on the planet where this had failed to happen. Of course, the deflection in this case should be toward the cliff; but even so, atmospheric whirls that would at least vary the speed of the wind greatly should be forming. What bothered them still more was the energy source of the current; they knew the heat output of 61 Cygni and the reflecting power of Mesklin's surface, and could account for most of the energy that struck the planet. There was not enough, at this point at least, to keep that wind going against ground friction. As the days went by they spent more and more time in the screen room, discussing the matter with each other and the Mesklinites who had learned English.

The river retained its width, as the Flyers had foretold; as they had also intimated was possible, it grew shallower and swifter. This should have slowed the *Bree* down, and actually did so; but not as much as it might have, for the wind began also to increase. Mile after mile went by, and day after day; and the meteorologists became frantic. Imperceptibly the sun crept higher in its circles about the sky, but much too slowly to convince those scientists that it was responsible for the increased wind force. It became evident to human beings and Mesklinites alike that something about the local physiography must be responsible; and at long last Barlennan became confident enough to slip briefly and land an exploring and hunting party, sure that the wind would still be there when he reembarked.

It was, and the miles flowed once more under the *Bree's* rafts. Eight hundred miles, the Flyers had said. The current of the river made the log indication much more than that,



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but at last the break that had been foretold appeared in the wall of rock, far ahead of them.

For a time the river flowed straight away from it, and they could see it in profile — a nearly straight slope, angling up at about twenty degrees, projecting from the bottom fifty feet of the cliff. As they approached, the course of the stream bent out away from the wall at last, and they could see that the slope was actually a fan-shaped spill radiating from a cleft less than fifty yards wide. The slope grew steeper within the cut, but might still be climbable; no one could tell until they were close enough to see what sort of debris composed the spill itself. The first near view was encouraging; where the river touched the foot of the slope, it could be seen to be composed of pebbles small even by the personal standards of the crew members. If they were not too loose, climbing should be easy.

Now they were swinging around to a point directly in front of the opening, and as they did so the wind at last began to change. It angled *outward* from the cliff, and its speed increased unbelievably. A roar that had sounded as a faint murmur for the last several days in the ears of crewmen and Earthmen alike now began to swell sharply, and as the *Bree* came directly opposite the opening in the rock the source of the sound became apparent.

A blast of wind struck the vessel, threatening to split the tough fabric of her sails and sending her angling across the stream away from the wall of rock. At the same instant the roar increased to almost explosive violence, and in the space of less than a minute the ship was struggling in a storm that vied with any she had encountered since leaving the equator.

It lasted only moments; the sails had already been set to catch a quartering wind, and they put enough upstream motion into the ship's path to carry her across the worst of the wind before she could run aground. Once out of it, Barlennan hastily turned his vessel to starboard and ran her across the short remaining distance to shore while he collected his wits. This accomplished, he did what was becoming a habit in unfamiliar situations; he called the Earthmen, and asked for an explanation. They did not disappoint him; the voice of one of the weathermen answered promptly, vibrant with the overtones the captain had learned to associate with human pleasure.

"That accounts for it, Barl! It's the bowl shape of that plateau! I should say that you'd find it easier to get along up there than we had believed. I can't see why we didn't think of it before!"

"Think of what?" The Mesklinite did not actually snarl, but his puzzlement showed clearly to the crew members who heard him.

"Think what a place like that could do in your gravity, climate, and



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atmosphere. Look: winter in the part of Mesklin you know — the southern hemisphere — coincides with the world's passage of its closest point to the sun. That's summer in the north, and the ice cap boils off — that's why you have such terrific and continual storms at that season. We already knew that. The condensing moisture — methane — whatever you want to call it gives up its heat and warms the air in your hemisphere, even though you don't see the sun for three or four months. The temperature probably goes up nearly to the boiling point of methane — around minus one forty-five at your surface pressure. Isn't that so? Don't you get a good deal warmer in winter?"

"Yes," admitted Barlennan.

"Very well, then. The higher temperature means that your air *doesn't* get thin so rapidly with altitude — you might say the whole atmosphere expands. It expands, and pours over the edge into that bowl you're beside, like water into a sinking soup plate. Then you pass the vernal equinox, the storms die out, and Mesklin starts moving away from the sun. You cool off — right? — and the atmosphere shrinks again; but the bowl has a lot caught inside, with its surface pressure now higher than at the corresponding level outside the bowl. A lot of it spills over, of course, and tends to flow away from the cliff at the bottom — but gets deflected to the left by the planet's spin. That's most of the wind that helped you along. The rest is this blast you just crossed, pouring out of the bowl at the only place it can, creating a partial vacuum on either side of the cleft, so that the wind tends to rush toward it from the sides. It's simple!"

"Did you think of all that while I was crossing the wind belt?" asked Barlennan drily.

"Sure — came to me in a flash. That's why I'm sure the air up there must be denser than we expected. See?"

"Frankly, no. However, if you are satisfied I'll accept it for now. I'm gradually coming to trust the knowledge of you Flyers. However, theory or no theory, what does this mean to us practically? Climbing the slope in the teeth of that wind is not going to be any joke."

"I'm afraid you'll have to. It will probably die down eventually, but I imagine it will be some months before the bowl empties — perhaps a couple of Earthly years. I can't even make an educated guess, at this point — I'd need measurements of the wind speed, the size of the opening, the volume of the basin, and a whole set of air-pressure values scattered all over the plateau itself. For all I know, it may not finish before next winter; almost certainly, now that I think of it, it will go on until midsummer, when you're farthest from the sun. That'll be the best part of two Earth-years from now.



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"I think, if it's at all possible for you, Barl, it would be worth attempting the climb without waiting."

The captain pondered this advice for some time. His desire to reach the rocket was unabated, of course; the idea of waiting some sixty thousand days for the wind to drop, with no assurance that it would do so even then, was far from encouraging. They could hardly lose by trying; after all, the wind merely added to the difficulty — it was no danger. At the Rim, of course, such a hurricane would pick up a Mesklinite bodily and drive him out of sight in seconds; but at the Rim such a wind could never form, since the air caught in the bowl would have only a tiny fraction of its present weight. That much even Barlennan now had clear.

"We'll go now," he said abruptly to the radio, and turned to give orders to the crew.

The *Bree* was guided across the stream — Barlennan had landed her on the side away from the plateau. There she was dragged well out of the river and her tie lines secured to stakes — there were no plants capable of taking the desired load growing this close to the landslide. Five sailors were selected to remain with the ship; the rest harnessed themselves, secured the drag-lines of their packs to the harness, and started at once for the slope.

For some time they were not bothered by the wind; Barlennan had made the obvious approach, coming up the side of the fan of rubble. Its farthest parts, as they had already seen, were composed of relatively fine particles — sand and very small pebbles; as they climbed, the rock fragments grew constantly larger. All could understand the reason for this; the wind could carry the smallest pieces farthest, and all began to worry a trifle about the size of the rocks they would have to climb over in the cut itself. Rocks that the wind they had felt could not move when intensified by its imprisonment between the walls of the cut must be monsters indeed.

Only a few days were consumed in reaching the side of the wall's opening. The wind was a little fresher here; a few yards on, it issued from behind the corner with a roar that made conversation even harder as they approached. Occasional eddies struck them, giving a tiny taste of what was to come; but Barlennan halted for only a moment. Then, making sure that his pack was close behind him and securely attached to his harness, he gathered himself together and crawled into the full blast of the wind. The others followed without hesitation.

Even to beings equipped with Mesklinite vocal apparatus the sound was deafening as the air currents sobbed past their bodies and around the scattered rocks. Their worst fears failed to materialize; climbing indi-



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vidual boulders was not necessary. Such huge fragments were present, indeed, but the downhill side of each was nearly covered by a ramp of finer material that had been swept into the relatively sheltered area by the everlasting wind. The ramps overlapped to a great extent, and where they did not it was always possible to travel across the wind from one to another. Their way was tortuous, but they slowly climbed.

They had to modify the original idea that the wind was not really dangerous. One sailor became hungry, paused in what he thought was shelter, and attempted to take a piece of food from his pack; an eddy around his sheltering rock, caused probably by his very presence which disturbed the equilibrium attained after months and years of steady wind, caught in the open container. It acted like a parachute, snatched its unfortunate owner out of his shelter and down the slope. He was gone from sight in a cloud of freshly disturbed, wind-lifted sand in moments, and his fellows looked away. A six-inch fall under this gravity could kill; there would be many such falls before their comrade reached the bottom. If by chance there were not, his own hundreds of pounds of weight would be scraped against the rocks hard enough and fast enough to accomplish the same end. The survivors dug their feet in a little farther, and gave up all thought of eating before they reached the top.

Time after time the sun crossed ahead of them, shining down the cleft. Time after time it appeared behind, blazing into the opening from the opposite direction. Each time the rocks about them lighted up under its direct impact they were a little farther up the long hill; each time, they began at last to feel, the wind was just a little less furious as it roared past their long bodies. The cleft was visibly wider, and the slope gentler. Now they could see the cliff opening out forward and to each side; at last, the way ahead of them became practically horizontal and they could see the broad regions of the upper plateau ahead.

The wind was still strong, but no longer deadly; and as Barlennan led the way to the left it decreased still further. It was not sharply defined here as it was below; it fed into the cleft from all directions, but from that very fact its strength decreased rapidly as they left the cut behind them. At long last they felt safe in stopping, and all immediately opened their packs and enjoyed a meal for the first time in some three hundred days — a long fast even for Mesklinites.

With hunger attended to, Barlennan began to look over the country ahead. He had stopped his group to one side of the cut, almost at the edge of the plateau, and the ground sloped down away from him around nearly half the compass. It was discouraging ground.



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The rocks were larger, and would have to be traveled around — climbing any of them was unthinkable. Even keeping to one direction among them would be impossible; no one could see more than a few yards in any direction once they surrounded him, and the sun was utterly useless as a means of guidance. It would be necessary to keep close to the edge — but not too close; Barlennan repressed an inward shudder. The problem of finding the rocket when they reached its neighborhood would have to be solved on the spot; the Flyers would surely be able to help there. Perhaps they could give him a radio signal whenever the sun was in the right direction, or something like that.

The next problem was food. There was enough in the packs for a long time — probably for the eight hundred miles back to the point above the *Bree's* old halting place; but there would have to be some means of replenishing the supply, for it would never last the round trip, or maintain them at the rocket for any length of time. For a moment Barlennan could not see his way through this problem; then a solution slowly grew on him. He thought it over from every angle, and finally decided it was the best that could be managed. Once settled on details, he called Dondragmer.

The mate had brought up the rear on the arduous climb, taking without complaint the bits of sand loosened by the others which had been hurled cruelly against him by the wind. He seemed none the worse for the experience, however; he could have matched the great Hars for endurance, if not for strength. He listened now to the captain's orders without any show of emotion, though they must have disappointed him deeply in at least one way. With his duties clear, he called together the members of his watch who were present, and added to them half the sailors of the captain's watch. Packs were redistributed; all the food was given to the relatively small group remaining with Barlennan, and all the rope except for a single piece long enough to loop through the harnesses of Dondragmer's entire company. They had learned from experience — experience they had no intention of repeating.

These preliminaries attended to, the mate wasted no time; he turned and led his group toward the slope they had just ascended with such effort, and presently the tail of the roped-together procession vanished into the dip that led to the cleft. Barlennan turned to the others.

"We will have to ration food strictly from now on. We will not attempt to travel rapidly; it would do us no good. The *Bree* should get back to the old stopping place well before us, but they will have some preparations to make before they can help us. You two who have radios, don't let anything happen to them; they're the only things that will let us find out when



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we're near the ship — unless someone wants to volunteer to look over the edge every so often. Incidentally, that may be necessary anyway; but I'll do it if it is."

"Shall we start right away, captain?"

"No. We will wait here until we know that Dondragmer is back to the ship. If he runs into trouble, we will have to use some other plan, which would probably require us to go back down ourselves; in that case it would be a waste of time and effort to have traveled any distance, and would cost time that might be valuable in getting back."

"I see."

The party settled down to wait, as comfortably as possible. Since the bare ground was little if any harder than the deck of the *Bree* where they normally relaxed, this was little hardship. None of them experienced any distress from the air density, which was fully as low as the Earthmen had predicted. Rosten watched them for minutes through one of the vision sets which was looking out of a pack, and finally turned away, shaking his head. There was a lot about the Mesklinite organism that needed research, and *that* would probably be hard to arrange.

Meanwhile, Dondragmer and his group reached the slope without difficulty. They stopped just long enough for the mate to make sure that all harnesses were securely fastened at regular intervals along the rope he had brought; then he attached his own at the rear, and gave the order to start down.

The rope proved a good idea; it was harder even for the many feet of the Mesklinites to keep their traction while heading downward than it had been before. The wind showed no tendency to pick anyone up this time, since they had no packs on which it could get a grip, but the going was still awkward. As before, everyone lost all track of time, and all were correspondingly relieved when the way opened ahead and they were able to swing to the left out of the wind's path. They still found themselves looking *down*, of course, which was extremely hard on Mesklinite nerves; but the worst of the descent was over.

Only three or four days were consumed in getting down the rest of the way and aboard the still waiting *Bree*. The sailors with the ship had seen them coming long enough in advance to develop a number of theories, mostly tragic in tone, concerning the fate of the rest of the party. They were quickly reassured, and the mate reported his arrival to the men on Toorey so that they could relay the information to Barlennan on the plateau. Then the ship was dragged back to the river — a real task, with a quarter of the crew missing and the full power of polar gravity



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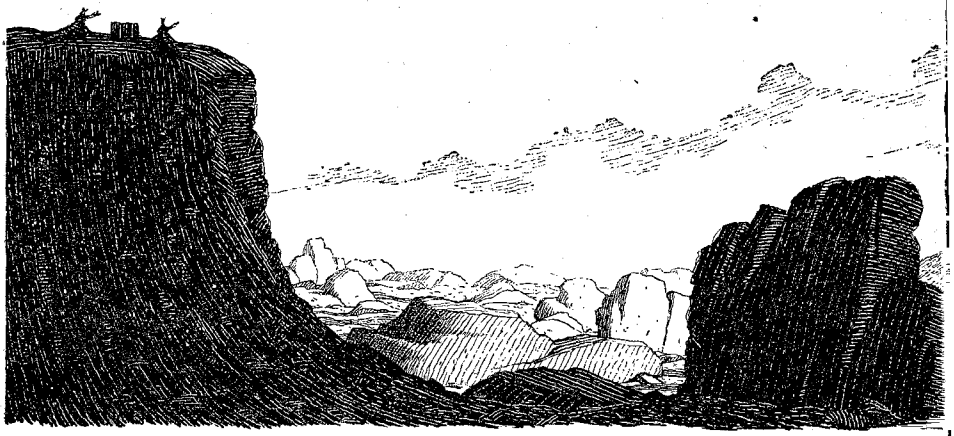

to plaster the rafts to the beach — but it was finally accomplished.

Twice the vessel hung up on small pebbles that had not quite stopped her going the other way; the first time a sailor swam across the river with a line which he fastened to a tree, and the differential hoist was put to effective use. The rig was left in place after the first obstruction was cleared, and was usable on the second with a minimum of delay.

With the *Bree* once more afloat, it was carefully salvaged; Dondragmer spent much of the time on the downstream trip examining it. He already knew its principles of construction well enough to have made one without help; but he could not quite figure out just *why* it worked. Several Earthmen watched him with amusement, but none was discourteous enough to show the fact — and none dreamed of spoiling the Mesklinite's chance of solving the problem by himself. Even Lackland, fond as he was of Barlennan, had long since come to the conclusion that the mate was considerably his captain's superior in general intelligence, and rather expected that he would be regaling them with a sound mechanical explanation before the *Bree* reached her former stopping place; but he was wrong.

As had already been pointed out by the ethnology department, the mate's general background did not include the concept of precise measurement of other than linear quantities, so that he was unable to form the concept of "work" in the sense in which physicists use the term. No doubt his race in a very few generations — Lackland had heard that before, and stopped worrying about the matter. By this time, the ship



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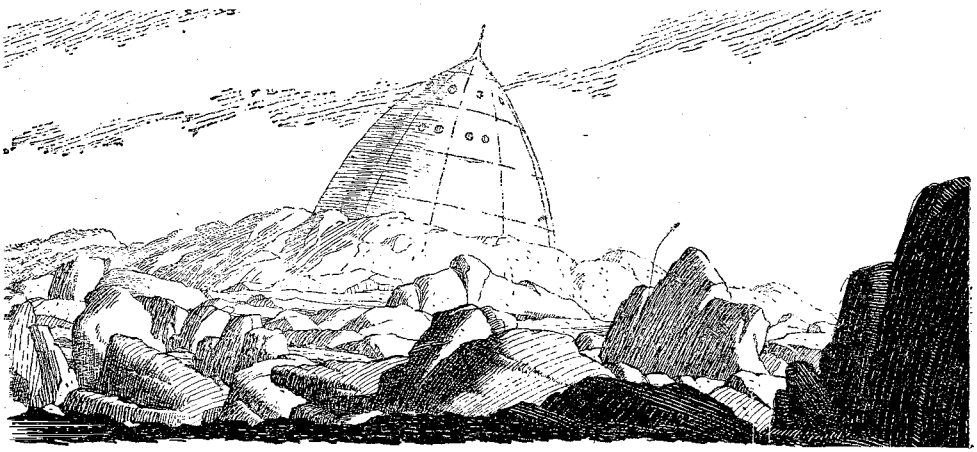

was almost to her destination, anyway.

The position of the grounded rocket was known with great accuracy; the uncertainty was less than half a dozen miles. Its telemetering transmitters — not all the instruments had been of permanent-record type — had continued to operate for more than an Earth-year after the failure to answer take-off signals; in that time, an astronomical number of fixes had been taken on the location of the transmitters. Mesklin's atmosphere did not interfere appreciably with radio, and the planet's rate of rotation was known to enough decimal places to present a clock-operated street-light control for the next five hundred years, if anyone wanted to.

The *Bree* could also be located by radio, as could Barlennan's party; it would be the job of the Earthmen to guide the two groups together and, eventually, lead them to the grounded research projectile. The difficulty was in obtaining fixes from Toorey; all three targets were on the "edge" of the disk as seen from the moon. Still worse, the shape of the planet meant that a tiny error in the determination of signal direction could mean a discrepancy of some thousands of miles on the world's surface; the line of the antenna just about grazed the flattest part of the planet. To remedy this, the rocket that had photographed the planet so much was launched once more, and set into a circular orbit that crossed the poles at regular intervals.

At first the idea had been to place the orbit outside the outer ring; but the pilot was good and crew willing, and when finally set up the craft threaded her way neatly through



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the narrow gap between the inner and second ring. It could not stay there indefinitely, of course; the same gravitational forces from Toorey that had swept the gap in the first place would eventually deflect the ship to the middle ring. However, she would be safe for several months, which should be long enough, even without course corrections.

From this orbit, once it was accurately set up, fixes could be taken with sufficient precision on the tiny transmitters that the Mesklinites were carrying with them.

The ship that was their goal was no longer transmitting, and its position known only in terms of the arbitrary co-ordinates that the expedition had set up for use on the planet; so the first thing the orbiting rocket did was send a set of fix times and directions to the satellite for the mathematicians to work on. In comparatively short order the relative positions of the three objects came back; a little later a revised map of the south polar regions was transmitted, having the arbitrary latitude and longitude grid added to the topography and the positions so far known carefully indicated. From now on actual positions could be figured in the rocket itself.

The problem became even simpler when Dondragmer finally brought the *Bree* to its former halting place and established a camp. There was now a fixed transmitter on the planet, and this made it possible to tell Barlennan how much farther he had to go within a minute or two of any time he chose to ask. The trip settled down to routine once more—from above.

## XVII.

For Barlennan himself it was hardly routine. The upper plateau was as it had seemed from the beginning; arid, stony, lifeless, and confusing. He did not dare go far from the edge; once among those boulders direction would quickly vanish. There were no hills of any size to serve as landmarks, or at least none which could be seen from the ground. The thickly scattered rocks hid everything more than a few yards away, towering into the line of sight in every direction except toward the edge of the cliff. They could not be climbed, in the hope of finding a better viewpoint; the very smallest, except for the almost solid paving of pebbles, was nearly a foot in height, and in this gravity not even the Mesklinites could raise more than an inch or two of their bodies from the ground at once. Also, in spite of the loss of much childhood conditioning, no one was really anxious to find himself a foot off the ground. Two dimensions, they felt, were enough for anyone, except in weird places like the Rim—and weirder ones where the Flyers came from.

Travel itself was not too difficult. The ground was level, except for the stones; these merely had to be avoided. Eight hundred miles is a long walk for



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a man, and a longer one for a creature only eighteen inches long who has to "walk" by rippling forward caterpillar style; and the endless detours made the actual distance covered much more than eight hundred miles. True, Barlennan's people could travel with considerable speed, all things considered; but much had to be considered.

The captain actually began to worry somewhat about the food supply before the trip was over. He had felt that he was allowing a generous safety margin when he first conceived the project; this idea had to be sharply modified. Time and again he anxiously asked the human beings far above how much farther he had to go; sometimes he received an answer—always discouraging—and sometimes the rocket was on the other side of the planet and his answer came from Toorey, telling him to wait a short time for a fix. The relay stations were still functioning, but they could not be used to take a directional reading on his radio.

It did not occur to him until the long walk was nearly over that he could have cut across among the stones after all. The sun by itself, of course, could not have served him as a directional guide; it circled the horizon completely in less than eighteen minutes, and a very accurate clock would be necessary to calculate the actual desired course from its apparent direction. However, the observers in the rocket could have told him at any time whether the sun was in front of him, behind him, or to a particular side with respect to his desired direction of travel. By the time this occurred to anyone, the remaining distance could be covered about as easily by keeping the edge in sight; the cliff was nearly straight between where Barlennan then was and the rendezvous point.

There was still a little food, but not too much, when they finally reached a position where the Earthmen could find no significant difference in the positions of the radios. Theoretically, the first thing to do should have been to proceed with the next phase of Barlennan's plan in order to replenish the supply of eatables; but actually there was a serious step to be taken first. Barlennan had mentioned it before the march began, but no one had really considered the matter with any care. Now it stared them in the eye.

The Earthmen had said they were about as close to the *Bree* as they could get. There should be, then, food only a hundred yards below them; but before they could take any steps toward getting it, someone—and probably several people—must *look over the edge*. They must *see* just where they were in relation to the ship; they must rig up lifting tackle to bring the food up; in short, they must look fully three hundred feet straight down—and they had excellent depth perception.

Acrophobia in a human being is usually considered a nervous disorder;



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in a Mesklinite it is one of the marks of a normal, healthy mind. The *Bree's* crew had always had it as much as any of their fellows; their experiences at the equator had not so much deprived them of it as tied it in with the variations of their body weight. Without weight, height was not dangerous; they had learned that, and come to accept it. Barlennan's expressed fear that they would forget the danger of height when weight came back to them now turned out to be unfounded. No one, including the captain, felt the least desire to go near the edge; anyone who found himself within three feet of it was visibly nervous over the fact. If any of them had ever seen such a thing as an overhanging cliff, they would probably never have gone that close.

Still, it had to be done; and, eventually, it was done. Barlennan, as befitted his position, set the example.

He went—not too rapidly, it must be admitted—to the three-foot limit and fixed his eyes on the low hills and other terrain features visible between him and the distant horizon. Slowly he let his gaze wander downward to closer and closer objects, until it was blocked by the lip of rock directly ahead of him. Without haste, he looked back and forth, getting used to seeing things that he could tell already were below him. Then, almost imperceptibly, he inched forward to take in more and more of the landscape near the foot of the cliff.

For a long time it looked generally the same, but he managed to keep his attention principally on the new details he could see rather than the fearful thing he was doing. At last, however, the river became visible, and he moved forward almost rapidly. The far bank was there; the spot where most of the hunting parties had landed after swimming across; from above, even the branching and rebranching trails they had left—he had never realized that such things showed so plainly from overhead.

Now the near bank could be seen, and the mark where the *Bree* had been drawn up before; a little farther—and the *Bree* herself was there, not a bit changed, sailors sprawled on her rafts or moving slowly about the bank in the neighborhood. For just an instant Barlennan forgot all about height and moved forward another body loop to call out to them. That loop put his head over the edge.

And he looked straight down the cliff.

He had thought that being lifted to the roof of the tank was the most hideous experience—at first—that he had ever undergone. He was never sure, after this, whether or not the cliff was worse. The mind has protection, like the fuses of electrical circuits; some memory records are shut off and never replayed. Barlennan was never sure just how he got back from the cliff face, and he never asked his men whether he had needed help.



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When he fully realized his surroundings once more he was a good, safe two yards from the edge, still shaking and uncertain of himself. It took days for his normal personality and thinking ability to resume course.

He finally decided what could—and must—be done. He had been all right merely looking at the ship; the trouble had occurred when his eyes actually had a line to follow between his own position and that remote lower level. The Earthman suggested this point, and after thought Barlennan agreed. That meant it was possible to do all that was necessary; they could signal the sailors below, and do any rope-pulling needed as long as they did not actually look down the cliff face itself. Keeping heads a safe couple of inches back from the rim was the key to sanity—and life.

Dondragmer had not seen his captain's head on its brief appearance, but he knew that the other party had arrived at the cliff top. He, too, had been kept informed of its progress by the Flyers. Now he and his crew began examining the edge of the rock wall above them with extreme care while those above pushed a pack to the extreme verge and moved it back and forth. It was finally seen from below, almost exactly above the ship; Barlennan had noticed before giddiness overwhelmed him that they were not exactly in the right spot, and the error had been corrected in showing the signal.

"All right, we have you." Dondragmer made the call in English, and it was relayed by one of the men in the rocket. An automatic relay that would permit one of the ground sets to be heard directly by the others was under construction but not yet complete; the sets themselves operated in different channels for sound as well as vision.

The sailor above thankfully stopped waving the empty pack, set it down projecting slightly over the edge so it could still be seen, and moved back to a safe distance from the verge. Meanwhile the rope that had been brought along was broken out. One end was bent firmly around a small boulder, Barlennan taking extreme pains with this operation; if the rope were lost, everyone on the plateau would almost certainly starve to death.

Satisfied at last on this matter, he had the rest of the cable carried close to the edge; and two sailors began carefully paying it over. Dondragmer was informed of their state of progress, but did not station anyone underneath to take the end as it came down. If anyone slipped above and the whole coil went over, the point immediately below could be rather uncomfortable, light as the cable was. He waited until Barlennan reported the line as completely paid out; then he and the rest of the crew went over to the foot of the cliff to find it. This was done without too much trouble, though the line was so thin as to be nearly invisible at any distance—it was the same material



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that had interested Lackland at the cliff thirty thousand miles to the north.

The extra rope had fallen into a tight bundle on the hard ground. Dondragmer's first act was to cut off the excess, straighten it out, and measure it. He had a very accurate idea now of the height of the cliff, for during the long wait he had had time to do much careful checking of shadow lengths. The Earthmen had offered to show him how the height could be measured in that way, and had been quite surprised to find that he already knew the method. Then they remembered that his people had sufficiently accurate surveys to have detected the curvature of Mesklin's surface—even if they did have it curving the wrong way—and the surprise vanished.

The excess rope proved to be insufficiently long to reach again the full height of the cliff; so the mate obtained another length from the *Bree*, made sure it was long enough, attached it to the section hanging from the cliff top, and informed the Earthmen that Barlennan could start pulling up.

It was a hard job, but not too hard for the powerful beings at the upper end; and in a relatively short time the second rope was at the top of the cliff and the worst fears of the captain were eased. Now if a cable were dropped they at least had a spare.

The second load was very different from the first, as far as ease of hoisting went. It was a pack loaded with food, weighing about as much as one of the sailors. Normally a single Mesklinite could not lift such a weight anywhere near this part of the planet, and the relatively small crew with Barlennan had their work cut out for them. Only by snagging the rope around a convenient boulder and taking frequent rests did they finally manage to get the load up to and over the edge, and when it was done the rope showed distinct signs of wear all along its length from contact with the boulder as well as the cliff edge itself. Something obviously had to be done, and while he and his group were celebrating the end of the strict food rationing Barlennan decided what it would have to be. He gave the appropriate orders to the mate after the feast.

The next several loads, in accordance with Barlennan's instructions, consisted of several masts and spars, more rope, and a number of pulleys of the sort they had used previously in lowering the *Bree* over the cliff at the distant equator. These were used to construct a tripod and hoist arrangement similar to what they had used before—very gingerly, since the pieces had to be lifted into position for lashing and the old prejudice against having solid objects overhead was present in full force.

Since the Mesklinites could not reach far from the ground now anyway, most of the lashing was done with the pieces involved lying flat; the assembly was then pried up into posi-



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tion with other spars as levers and boulders which had been laboriously rolled to convenient locations as fulcrums. A similar team of men, working under their natural conditions, could have done a corresponding job in an hour; it took the Mesklinites many times as long—and none of the watching Earthmen could blame them.

The tripod was assembled and erected well back from the edge, then inched laboriously into position as close to that point as could be managed and its legs propped in place with small boulders which the watching men classed mentally as pebbles. The heaviest of the pulleys was attached to the end of a mast as firmly as possible, the rope threaded through it, and the mast levered into position so that about a quarter of its length projected over the abyss past the supporting tripod. Its inner end was also weighted in place with the small stones.

Much time was consumed in this work, but it proved worth while. Only a single pulley was used at first, so the hoisting crew still had their load's full weight to handle; but the friction was largely eliminated, and a cleat attached to the inner end of the mast simplified the holding problem while the crew rested. Also, the increased speed made possible by the reduced friction encouraged smaller individual loads. The differential pulley was not employed at first, since it would have had to be reset over two hundred times in raising a burden the height of the cliff; but both Barlennan and his mate kept it in mind as a possibility if some very large object that could not be divided into several loads had to be raised. Neither worried about the strength of the rope; and Lackland, who had seen the results of tests run on the sample he had obtained, did not worry either. He intended to discuss that rope with Barlennan at some more suitable opportunity.

Load after load of supplies came up, while the crew below hunted and fished endlessly to keep the stream flowing. The area around the hoisting tackle began to take on a settled appearance; indeed, most of the sailors found time between spells at the rope to erect inch-high walls of pebbles around selected areas of their own so that the neighborhood came gradually to resemble more than slightly one of the cities of their own land. No fabric was available for roofs—or rather, Barlennan wasted no effort bringing any up from below—but in other respects the enclosures were almost homelike.

The supplies on hand were already more than one person could conveniently carry; Barlennan planned to establish caches along the route to the rocket. The journey was not expected to be as long as from the cleft they had climbed, but their stay at the site of the crippled machine would be



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long, and every provision to make it safe was to be taken. Actually, Barlennan would have liked a few more men on the plateau, so that he could leave some at the hoist and take others with him; but there were certain practical difficulties connected with that. For another group to travel up to the cleft, climb it, and come back to their present station seemed too lengthy a job; nobody liked to think of the alternative, which was to haul people up on the hoist as they had gone down earlier with the *Bree*. Barlennan, of course, did think of this; but an experiment on the part of one of the crew made it a difficult subject to broach.

That individual, after getting his captain's approval—Barlennan regretted giving it later—and having the crewmen below warned away, had rolled a bullet-sized pebble to the edge of the cliff and given it a final shove. The results had been interesting, both to Mesklinites and Earthmen. The latter could see nothing, since the only view set at the foot of the cliff was still aboard the *Bree* and too distant from the point of impact to get a distinct view; but they heard as well as the natives. As a matter of fact, they saw almost as well; for even to Mesklinite vision the pebble simply vanished. There was a short note like a breaking violin string as it clove the air, followed a split second later by a sharp report as it struck the ground below.

Fortunately it landed on hard, slightly moist ground rather than on another stone; in the latter case, there would have been a distinct chance of someone's being killed by flying splinters, though all had withdrawn to a relatively safe distance—they assumed. The impact, at a speed of approximately a mile a second, sent the ground splashing outward in a wave too fast for any eye to see while it was in motion, but which froze after a fraction of a second leaving a rimmed crater surrounding the deeper hole the missile had drilled in the soil. Slowly the sailors gathered around, eying the gently steaming ground; then with one accord they moved a few yards away from the foot of the cliff. It took some time to shake off the mood that experiment engendered.

Nevertheless, Barlennan wanted more men at the top; and he was not the individual to give up a project for fear it might not work. He came out with the proposal of an elevator one day, met the expected flat silence, but continued to revert to the subject at regular intervals as the work went on. As Lackland had long since noted, the captain was a persuasive individual. It was a pity that the present job of persuasion was done in the native language, for the men would greatly have enjoyed hearing Barlennan's remarkably varied and original approaches and seeing his listeners go from utter refusal to consider, through



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unsympathetic listening, to grudging consent. They never became enthusiastic partisans of the idea, but Barlennan did not expect miracles anyway.

Actually, it is very likely that his success was not entirely due to his own efforts. Dondragmer badly wanted to be among those present when the rocket was reached; he had been extremely unhappy at being ordered back down with the group that returned to the ship, though his ingrained dislike of people who argued against orders had prevented his allowing his feelings to show. Now that there seemed to be a chance to get back to the active group, as he looked on it, he found it much easier than might otherwise have been the case to persuade himself that being pulled up a cliff on the end of a rope really wasn't so bad. In any case, he reflected, if the rope broke he'd never know it.

He therefore became a disciple of the captain's views among the sailors at the bottom of the cliff; and as they realized that their senior officer intended to go first, and actually seemed to *want* to go, much of their natural sales resistance disappeared. The automatic relays had now been completed, and Barlennan could talk directly to the other group, so his full strength of personality could also come into play.

The upshot was that a small wooden platform was constructed with a low, solid railing—Dondragmer's invention—that would prevent anyone from seeing down once he was inside. The whole arrangement was supported in a rope sling that would hold it in a horizontal position; this was a relic of the previous hoisting experience at the equator.

The platform, all ropes and knots carefully tested by a tug-of-war that greatly interested the human spectators, was dragged over beneath the hoist and attached to the main rope. At the request of the mate, some slack was given from above and the last knot tested in the same fashion as the others; satisfied that all was secure, Dondragmer promptly climbed onto the platform, put the last section of railing in place, and gave the signal to hoist. The radio had been dragged over from the ship; Barlennan heard the mate directly. He joined his crew at the rope.

There was practically no swinging, anyway; Dondragmer remembered how uncomfortable that had been the last time he had been on such a device. Here the wind, though still blowing steadily along the cliff, was unable to budge perceptibly the pendulum of which he was a part; its cord was too narrow to furnish a grip for air currents, and the weight of its bob too enormous to be easily shifted by them.

This was fortunate not merely from the point of view of comfort; if a swing had started from any cause, its



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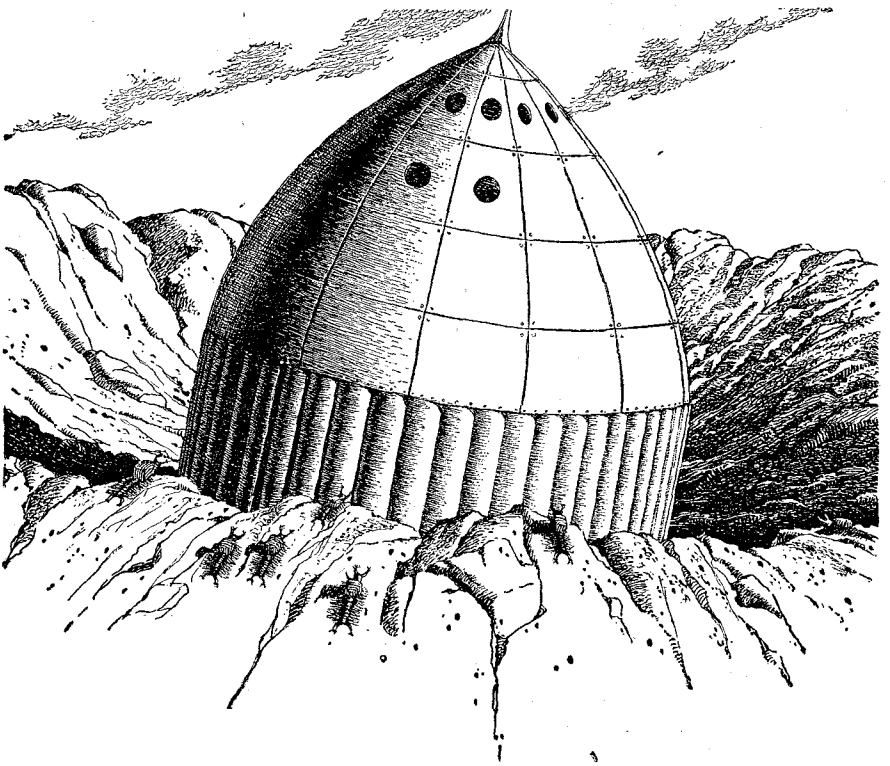

period would have been around half a second at the start and decreased as he ascended to a value that would have amounted to nearly sonic vibration and almost certainly pulled the structure at the top from its foundations. The only reason the Mesklinites had not found this out already from experience was that the rope on its way down was held so nearly vertical by the gravity that any swing begun as its next load lifted and tried to center under the pulley was completely negligible.

Dondragmer was a being of straightforward, practical intelligence, and he made no attempt to do any sightseeing as he ascended. On the contrary, he kept his eyes carefully closed, and was not ashamed to do so. The trip seemed endless, of course; in actual fact, it took about six days. Barlennan periodically stopped proceedings while he inspected the hoist and its anchorage, but these were always sound. The weight of stones now piled about the legs of the tripod and on the rear end of the supporting mast



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considerably exceeded that of the present load, anyway.

At long last the platform appeared above the edge of the cliff and its supporting sling reached the pulley, preventing any further elevation. The edge of the elevator was only an inch or so from the cliff; it was long and narrow, to accommodate the Mesklinite form, and a push on one end with a spar sent the other swinging over solid ground. Dondragmer, who had opened his eyes at the sound of voices, crawled thankfully off and away from the edge.

The watching Lackland announced his safety even before Barlennan could do so to the waiting sailors below, and his words were at once translated by one who knew some English. They were relieved, to put it mildly; they had seen the platform arrive, but could not tell the condition of its passenger. Barlennan took advantage of their feelings, sending the lift down as fast as possible and starting another passenger up.

The whole operation was completed without accident; ten times in all, the elevator made its trip before Barlennan decided that there could be no more taken from below without making the supply job of those who remained too difficult. Actually, he may have been influenced by other factors; he was not sorry to be able to ease the tension which inevitably accompanied the hauling of a friend through a hundred yards of empty air. It had been harder on him and his crew than those below, in one way; the operators of the elevator could not see just how much farther they had to go, and the amount of rope coiled behind them gave only a rough idea. Each time the platform rose suddenly into view it brought with it an indescribable surge of relief.

The tension was over now, however, and once again a feeling that they were in the final stages of the mission spread through Earthmen and natives alike. Men were ready; food was ready for the start, and provision for its replenishment from the river below had been made; the rocket circling in free fall beyond the atmosphere was ready to supply what guidance it could. Rosten was holding in his impatience with considerable effort, though Barlennan did not know that. The captain simply made sure that all was ready, selected the group that was to remain to handle the hoist, ordered packs attached to harnesses, and called the Earthmen for instructions. The men were ready.

"If you'll wait about two minutes, Barl," Lackland relayed the information given him by one of the computers, "the sun will be exactly on the direction line you should follow. We've warned you that we can't pin the rocket down closer than about six miles; we'll guide you into the middle of the area that we're sure contains it, and you'll have to work out your



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own search from there. If the terrain is at all similar to what you have where you are now, that will be rather difficult, I fear."

"You are probably right, Charles; we have had no experience with such matters. Still, I am sure we will solve that problem; we have solved all others—frequently with your help, I confess. Is the sun in line yet?"

"Just a moment—there! Is there any landmark even reasonably distant which you can use to hold your line until the sun comes around again?"

"None, I fear. We will have to do the best we can, and take your corrections each day."

"That's a bit like dead reckoning where you don't know the winds or currents, but it will have to do. We'll correct our own figures every time we can get a fix on you. Good luck!"

## XVIII.

Direction was a problem, as all concerned found out at once. It was physically impossible to maintain a straight line of travel; every few yards the party had to detour around a boulder that was too high to see or climb over. The physical structure of the Mesklinites aggravated the situation, since their eyes were so close to the ground. Barlennan tried to make his detours in alternate directions, but he had no means of checking accurately the amount of each one. It was a rare day when the direction check from the rocket did not show them to be twenty or thirty degrees off, usually to the left. Lackland transmitted the last fact to Toorey for Rosten to play with; it might keep his mind off his other troubles.

About every fifty days a check was made on the position of the transmitter—there was only one moving now; another had been left with the group at the hoist—and a new direction computed. High-precision work was required, and occasionally some doubt was felt about the accuracy of a given fix. When this happened Barlennan was always warned, and left to his own discretion. Sometimes, if the Earthmen did not sound too doubtful of their own work, he would go on; at others, he would wait for a few days to give them a chance for a better fix. While waiting he would consolidate his position, redistributing pack loads and modifying the food rations when it seemed necessary. He had hit upon the idea of trail blazing almost before starting, and a solid line of pebbles marked their path from the edge. He had the idea of eventually clearing all the stones from a path and heaping them on each side, thus making a regular road; but this would be later, when trips back and forth between the grounded rocket and the supply base became regular.

There was still no plant or animal life, and no moisture. The latter fact would have made the place impenetrable to human beings equipped as



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were the Mesklinites, but the food the latter ate supplied much of the moisture the caterpillarlike bodies needed and Barlennan's people kept on.

The fifty miles passed slowly under their many feet, but pass it finally did. The men, as Lackland said, had done all they could; to the best of their ability to measure, Barlennan should now be standing beside the stranded machine. Both the vision set and the captain's voice clearly informed him that no such state of affairs existed, which did not surprise him at all.

"That's the best we can do, Barl. I'll swear, knowing our math boys, that you're within six miles of that gadget, and probably a good deal less. You can organize your men better than I for a search which will have a minimum chance of losing any of them and a maximum chance of finding what we want; I won't try to interfere there. Anything we can do we certainly will, but I can't imagine what it might be at this point. How do you plan to arrange matters?"

Barlennan paused before answering. A six-mile circle is an appalling area to search when visibility averages three or four yards. He could cover territory most rapidly, of course, by spreading out his men; but that raised to the point of near certainty the chance of losing some of them. They had already tried using voice as a directional guide, and found that the larger boulders produced such a multiplicity of echoes as to render the method nearly useless even for furnishing a single direction line; with sailors all around, there would be no hope of guiding any one in the right direction if he became confused. He put this point up to Lackland.

"The rocket itself is about twenty feet tall," the man pointed out. "For practical purposes your vision circle is therefore larger than you say. Your point about echoes is certainly true; I heard your experiments, as you say. If you could only get up on one of those larger boulders you'd probably see the ship from where you are—that's what's so annoying about the whole situation."

"Of course; but we can't do that. The large rocks are six or eight of your feet in height; even if we could climb their nearly vertical sides, I would certainly never again look down a straight wall, and will not risk having my men do so."

"Yet you climbed that cleft up to the plateau."

"That was different. We were never beside an abrupt drop. We knew in our minds that a roll down such a slope would be as bad as a fall, but it didn't look the same—and the danger of actually losing hold on such a surface was practically nothing, unless something actually pulled you away."

"Then if a similar slope led up to one of these boulders, you wouldn't mind getting that far from the ground?"



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"No, but—hm-m-m. I think I see what you're driving at. Just a moment." The captain looked at his surroundings more carefully. Several of the great rocks were nearby; the highest, as he had said, protruded some six feet from the hard ground. Around and between them were the ever-present pebbles that seemed to floor the whole plateau. Possibly if Barlennan had ever been exposed to solid geometry he would not have made the decision he did; but having no real idea of the volume of building material he was undertaking to handle, he decided that Lackland's idea was sound.

"We'll do it, Charles. There's enough small rock and dirt here to build anything we want." He turned from the radio and outlined the plan to the sailors.

If Dondragmer had any doubts about its feasibility he kept them to himself; and presently the entire group was rolling stones. Those closest to the selected rock were moved close against it, and others against these, until a circle of bare ground began to spread outward from the scene of operations. Periodically a quantity of the hard soil was loosened by harder pincers and spread onto the layer of small rocks; it was easier to carry and filled more space—until the next layer of stone tamped it down.

Progress was slow, but steady; the Earthmen watched in amazement at the antlike persistence and energy the sailors and their officers displayed. The workers discovered for themselves that the further they got the faster they seemed to go—a natural fact resulting from the geometry of cones—and the discovery boosted morale. Some indication of the time it took may be gained from the fact that at one point part of the group had to be sent back along the blazed trail for further food supplies—a thing which had been unnecessary in the eight-hundred-mile walk from the cleft; but at last the relatively flat top of the boulder felt the tread of feet, probably for the first time since the inner energies of Mesklin had pushed the plateau to its present elevation. The ramp spread down and to each side from the point of access; no one approached the other side of the boulder, where the drop was still sheer.

No one, actually, was interested in his standing place; for from the new vantage point Lackland's prediction was fulfilled—after months of travel and danger, the goal of the expedition was in sight. Barlennan actually had the vision set hauled up the ramp so the Earthmen could see it, too; and for the first time in over an Earth-year, Rosten's face lost its habitual grim expression. It was not much to see; perhaps one of the Egyptian pyramids, plated with metal and placed far enough away, would have looked somewhat like the blunt cone that lifted above the intervening stones. It did not resemble the rocket Barlennan



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had seen before—in fact, it did not greatly resemble any rocket previously built within twenty light-years of Earth; but it was obviously something that did not belong to Mesklin's normal landscape, and even the expedition members who had not spent months on the monstrous planet's surface seemed to feel weight roll from their shoulders.

Rosten was almost gay; Lackland and the computers in the rocket were grinning broadly; even the ethnology department was distracted from the screen which still showed scenes in the river village. The joy was not confined to human beings; representatives of the other worlds which had contributed to the initial experiment and the recovery attempt were equally overjoyed. A bulky, furred native of the heavy inner planet of Groombridge 1618 linked appendages with a pair of hard-shelled, three-foot-high scientists from Altair V and performed something that was presumably the equivalent of a dance of joy.

Barlennan, though pleased, did not share the abandon that was approaching party intensity on Toorey. He was better able than those whose view depended on television to judge just what lay between his present position and the rocket. This appeared no worse than what they had already crossed, but it was certainly no better. There would no longer be the Earthmen's guidance, either; and even with the present vantage point, he could not quite see how the party was to maintain its line of march for the mile and a half that they would have to travel.

The men did not actually know the direction now, so their method would not work—or would it? He could *tell them* when the sun lay in the right direction; after that they could call him each time it passed through the same bearing. For that matter, one man could stay here and give the same information without bothering the Flyers—but wait; he had only one radio now. It could not be in both places at once. For the first time Barlennan really missed the set that had been left with the river-dwellers.

Then it occurred to him that he might not need a radio. True, the air did not carry sound so well here—it was the only aspect of the thinner atmosphere of the plateau that the sailors had noticed at all—but the Mesklinite voice, as Lackland had remarked, was something that had to be heard to be believed. The captain decided to try it; he would leave one man here on the lookout platform, whose duty would consist of hooting with all the energy the muscles around his swimming-siphon could muster each time the sun passed straight above the gleaming cone that was their goal. The trail would be blazed as before so that he could follow when the others arrived.

Barlennan outlined this idea to the



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group. Dondragmer pointed out that on the basis of past experience they might even so go too far to one side, since there would be no way of making fixes as the Earthmen had done to correct cumulative errors; the fact that the watcher's voice did not sound from directly opposite the sun at any time would mean nothing in this echo-rich neighborhood. He admitted, however, that it was the best idea so far, and did stand a good chance of bringing them within sight of the rocket. A sailor was chosen, therefore, to man the observation post, and the trip was resumed in the new direction.

For a short distance the post itself remained in sight, and it was possible to judge the error that had crept into their course each time the sailor's voice was heard. Presently, however, the rock on which he was standing was lost behind others of equal size, and navigation settled down to the task of making sure they were heading as closely as possible toward the sun each time the echoing hoot sounded in their ears. The sound grew weaker as the days passed, but with no other sounds on the lifeless plateau to cover it there was never any doubt of what they heard.

None of them even yet considered themselves experienced enough in land travel to estimate accurately the distance covered, and all were used to arriving much later than original hopes called for; so the group was pleasantly surprised when finally the monotony of the desert of stone was broken by a change in the landscape. It was not exactly the change that had been expected, but it attracted attention for all that.

It was almost directly ahead of them, and for a moment several of the group wondered whether they had in some incomprehensible way traveled in a circle. A long slope of mixed dirt and pebbles showed between the boulders. It was about as high as the one they had built to the observation station; but as they approached they saw it extended much farther to each side—as far, in fact, as anyone could see. It lapped around large boulders like an ocean wave frozen in mid-motion; even the Mesklinites, totally unused to explosion or meteor craters, could see that the material had been hurled outward from some point beyond the slope. Barlennan, who had seen rockets from Toorey land more than once, had a pretty good idea of the cause and of what he was going to see even before the party topped the rise. He was right in general, if not in detail.

The rocket stood in the center of the bowl-shaped indentation that had been blasted by the fierce wash of her supporting jets. Barlennan could remember the way snow had swirled out of the way when the cargo rocket landed near Lackland's "Hill." He could appreciate the fact that the lifting power used here must have been



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far mightier in order to ease the bulk of this machine down, smaller though it was. There were no large boulders near it, though a few reared up near the sides of the bowl. The ground inside was bare of pebbles; the soil itself had been scooped out so that only four or five of the projectile's twenty feet of height rose above the general run of rocks covering the plain.

Its base diameter was almost as great as its height, and remained so for perhaps a third of the way upward. This, Lackland explained when the vision set had been brought to bear on the interior of the blast crater, was the part housing the driving power. He went on to say things about iron-hydrogen clathrate slugs which meant nothing whatever to his Mesklinite listeners and very little to himself, since he was not a physical chemist.

The upper part of the machine narrowed rapidly to a blunt point, and this housed the apparatus which represented such a tremendous investment in time, intellectual effort, and money on the part of so many worlds. A number of openings existed in this part, as no effort had been made to render the compartments airtight. Such apparatus as required either vacuum or special atmosphere in which to function was individually sealed.

"You said once, after the explosion in your tank that wrecked it so completely, that something of the sort must have happened here," Barlennan said. "I see no signs of it; and if the holes I see were open when you landed it, how could enough of your oxygen still be there to cause an explosion? You told me that beyond and between worlds there was no air, and what you had would leak out through any opening."

Rosten cut in before Lackland could answer. He and the rest of the group had been examining the rocket on their own screen.

"Barl is quite right. Whatever caused the trouble was not an oxygen blast. I don't know what it was, but I'm glad it happened."

"Why?" Lackland wanted to know. "I'm not sorry to have met Barlennan and his people, but it's held us up a year and a half."

"If that machine had tried to blast off when we sent the signal, there'd have been nothing to salvage. You saw that ship in space before it was landed; you must remember the metal legs that were projecting among the tubes to keep her above ground and the tube mouths clear. There must have been two hundred of them. You can see for yourself that the thing has settled into the ground clear to—and I should say somewhat past—the nozzles. I know hydroferron is a directional explosive, but you can't make me believe she'd have held together if the tubes had fired in that situation." Lackland looked startled, realizing for the first time that his chief was right. "Some engineers are going to have a



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lot of explaining to do," Rosten added. "Those legs were supposed to hold the ship on any reasonably hard ground up to two thousand gravities—three times what they actually had to take. Someone missed a decimal point, which won't help his earning capacity for a few years."

"Was there any sort of automatic safety which would prevent the tubes from firing in such an event?" asked Lackland. "That would account for her failure to start."

"There was not, to my knowledge. We'll just have to keep our eyes open when we go inside, in the hope of finding the trouble—not that it will matter much by then, except to people who want to build another of these things. I'd say we might as well get to work; I have a horde of physicists on my neck simply quivering for information. It's lucky they put a biologist in charge of this expedition; from now on there won't be a physicist fit to approach."

"Your scientists will have to contain themselves a little longer," Barlennan interjected. "You seem to have overlooked something."

"What?"

"Not one of the instruments you want me to put before the lens of your vision set is within seven feet of the ground; and all are inside metal walls which I suspect would be rather hard for us to remove by brute force, soft as your metals seem to be."

"Blast it, you're right, of course. The second part is easy; most of the surface skin is composed of quick-remove access plates that we can show you how to handle without much trouble. For the rest—hm-m-m. You have nothing like ladders, and couldn't use them if you had. Your elevator has the slight disadvantage of needing at least an installation crew at the top of its travel before you can use it. Offhand, I'm afraid I'm stuck for the moment. We'll think of something, though; we've come too far to be stumped now."

"I would suggest that you spend from now until my sailor gets here from the lookout in thought. If by that time you have no better idea, we will use mine."

"What? You have an idea?"

"Certainly. We got to the top of that boulder from which we saw your rocket; what is wrong with using the same method here?"

Rosten was silent for fully half a minute; Lackland suspected he was kicking himself mentally.

"I can only see one point," he said at last. "You will have a much larger job of rock-piling than you did before. The rocket is more than three times as high as the boulder where you built the ramp, and you'll have to build up all around it instead of on one side, I suspect."

"Why can we not simply make a ramp on one side up to the lowest level containing the machines you are interested in? It should then be possible



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to get up the rest of the way inside, as you do in the other rockets."

"For two principal reasons. The more important one is that you won't be able to climb around inside; the rocket was not built to carry living crews, and has no communication between decks. All the machinery was built to be reached from outside the hull, at the appropriate level. The other point is that you cannot start at the lower levels; granted that you could get the access covers off, I seriously doubt that you could lift them back in place when you finished with a particular section. That would mean that you'd have the covers off all around the hull before you built up to the next level; and I'm rather afraid that such a situation would not leave enough metal in place below to support the sections above. The top of the cone would—or at least might—collapse. Those access ports occupy the greater part of the skin, and are thick enough to take a lot of vertical load. Maybe it was bad design, but remember we expected to open them only in space, with no weight at all.

"What you will have to do, I fear, is bury the rocket completely to the *highest* level containing apparatus and then dig your way down, level by level. It may even be advisable to remove the machinery from each section as you finish with it; that will bring the load to an absolute minimum. After all, there'll only be a rather frail-looking skeleton when you have all those plates off, and I don't like to picture what would happen to it with a full equipment load times seven hundred, nearly."

"I see." Barlennan took his turn at a spell of silent thought. "You yourself can think of no alternative to this plan? It involves, as you rightly point out, much labor."

"None so far. We will follow your recommendation, and think until your other man comes from the observation point. I suspect we work under a grave disadvantage, though—we are unlikely to think of any solution which does not involve machinery we couldn't get to you."

"That I had long since noticed."

It was impossible to tell whether the Mesklinite made the statement as one of simple fact or a vehicle for sarcasm. No one attempted to ask; only Rosten so much as raised his eyebrows, and that was a harmless gesture since Barlennan had no vision receiver. The native's remark was undoubtedly true, whatever he had meant by it.

The sun continued to circle the sky at a shade better than twenty degrees a minute. A call had long since gone echoing out to the observation platform to let the guide know his work was done; he was presumably on the way in. The sailors did nothing except rest and amuse themselves; all, at one time or another, descended the easy slope of the pit the blasts had dug to examine the rocket at close quarters. All of them were too intelligent to put



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its operation down to magic, but it awed them nonetheless. They understood nothing of its principle of operation, though that could easily have been made clear if Lackland had stopped to wonder how a race that did not breathe could nevertheless speak aloud. The Mesklinites possessed in well developed form the siphon arrangement, similar to that of Earthly cephalopods, which their amphibious ancestors had used for high speed swimming; they used it as the bellows for a very Earthly set of vocal cords, but were still able to put it to its original function. They were well suited by nature to understand the rocket principle.

Their lack of understanding was not all that aroused the sailors' respect. Their race built cities, and they had regarded themselves as good engineers; but the highest walls they ever constructed reached perhaps three inches from the ground. Multistoried buildings, even roofs other than a flap of fabric, conflicted too violently with their almost instinctive fear of solid material overhead. The experiences of this group had done something to change the attitude from one of unreasoning fear to one of intelligent respect for weight, but the habit clung nevertheless. The rocket was some eighty times the height of any artificial structure their race had ever produced; awe at the sight of such a thing was inevitable.

The arrival of the lookout sent Barlennan back to the radio, but there was no better idea than his own to be had. This did not surprise him at all. He brushed Rosten's apologies aside, and set to work along with his crew. Not even then did any of the watchers above think of the possibility of their agent's having ideas of his own about the rocket. Curiously enough, such a suspicion by then would have come much too late—too late to have any foundation.

Strangely, the work was not as much harder or longer as everyone had expected. The reason was simple; the rock and earth blown out by the jets was relatively loose, since there was no weather in the thin air of the plateau to pack it down as it had been before. A human being, of course, wearing the gravity nullifier the scientists hoped to develop from the knowledge concealed in the rocket, could not have pushed a shovel into it, for the gravity was a pretty good packing agent; it was loose only by Mesklinite standards. Loads of it were being pushed down the gentle inner slope of the pit to the growing pile around the tubes; pebbles were being worked clear of the soil and set rolling the same way, with a hooted warning beforehand. The warning was needed; once free and started, they moved too fast for the human eye to follow, and usually buried themselves completely in the pile of freshly moved earth.

It became evident to the watchers



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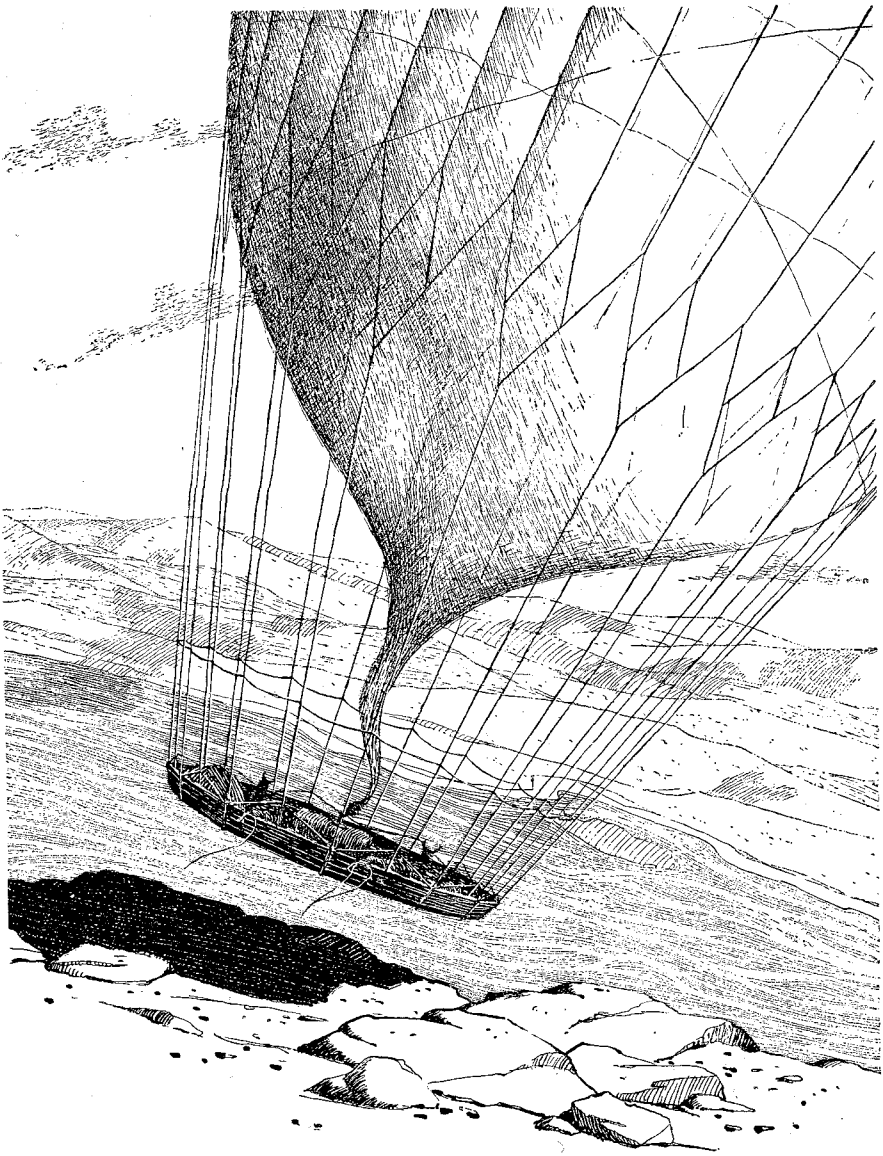



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that this could go on indefinitely; at considerably less than the steepest slope the sailors seemed willing to tolerate, the heaped-up ring around the crater would provide ample material for the mound. Even the most pessimistic of the watchers began to feel that no more setbacks could possibly occur, in spite of the number of times they had started to unpack shelved apparatus and then had to put it away again. They watched now with mounting glee as the shining metal of the research projectile sank lower and lower in the heap of rock and earth, and finally vanished entirely except for a foot-high cone that marked the highest level in which machinery had been installed.

At this point the Mesklinites ceased work, and most of them retreated from the mound. The vision set had been brought up and was now facing the projecting tip of metal, where part of the thin line marking an access port could be seen. Barlennan sprawled alone in front of the entrance, apparently waiting for instructions on the method of opening it; and Rosten, watching as tensely as everyone else, explained to him. There were four quick-disconnect fasteners, one on each corner of the trapezoidal plate. The upper two were about on a level with Barlennan's eyes; the others some six inches below the present level of the mound. Normally they were released by pushing in and making a quarter turn with a broad-bladed screwdriver; it seemed likely that Mesklinite pincers could perform the same function. Barlennan, turning to the plate, found that they could. The broad, slotted heads turned with little effort and popped outward, but the plate did not move otherwise.

"You had better fasten ropes to one or both of those heads, so you can pull the plate outward from a safe distance when you've dug down to the others and unfastened them," Rosten pointed out. "You don't want that piece of hardware falling on top of anyone; it's a quarter of an inch thick. The lower ones are a darned sight thicker, I might add."

The suggestion was followed, and the earth scraped rapidly away until the lower edge of the plate was uncovered. The fasteners here proved no more troublesome than their fellows, and moments later a hard pull on the ropes unseated the plate from its place in the rocket's skin. For the first fraction of an inch of its outward motion it could be seen; then it vanished abruptly, and reappeared lying horizontally while an almost riflelike report reached the ears of the watchers. The sun, shining into the newly opened hull, showed clearly the single piece of apparatus inside; and a cheer went up from the men in the screen room and the observing rocket.

"That did it, Barl! We owe you more than we can say. If you'll stand back and let us photograph that as it is, we'll start giving you directions for



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taking out the record and getting it to the lens." Barlennan did not answer at once; his actions spoke some time before he did.

He did not get out of the way of the eye. Instead he crawled toward it and pushed the entire set around until it no longer covered the nose of the rocket.

"There are some matters we must discuss first," he said quietly.

## XIX.

Dead silence reigned in the screen room. The head of the tiny Mesklinite filled the screen, but no one could interpret the expression on the completely unhuman "face." No one could think of anything to say; asking Barlennan what he meant would be a waste of words, since he obviously planned to tell anyway. He waited for long moments before resuming his speech; and when he did, he used better English than even Lackland realized he had acquired.

"Dr. Rosten, a few moments ago you said that you owed us more than you could hope to repay. I realize that your words were perfectly sincere in one way—I do not doubt the actuality of your gratitude for a moment—but in another they were merely rhetorical. You had no intention of giving us any more than you had already agreed to supply—weather information, guidance across new seas, possibly the material aid Charles mentioned some time ago in the matter of spice collecting. I realize fully that by your moral code I am entitled to no more; I made an agreement and should adhere to it, particularly since your side of the bargain has largely been fulfilled already.

"However, I want more; and since I have come to value the opinions of some, at least, of your people I want to explain why I am doing this—I want to justify myself, if possible. I tell you now, though, that whether I succeed in gaining your sympathy or not, I will do exactly as I planned.

"I am a merchant, as you well know, primarily interested in exchanging goods for what profit I can get. You recognized that fact, offering me every material you could think of in return for my help; it was not your fault that none of it was of use to me. Your machines you said would not function in the gravity and pressure of my world; your metals I cannot use—and would not need if I could; they lie free on the surface in many parts of Mesklin. Some people use them for ornaments; but I know from talk with Charles that they cannot be fashioned into really intricate forms without great machines, or at least more heat than we can easily produce. We do know the thing you call fire, by the way, in ways more manageable than the flame cloud; I am sorry to have deceived Charles in that matter, but it seemed best to me at the time.

"To return to the original subject, I



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refused all but the guidance and weather information of the things you were willing to give. I thought some of you might be suspicious of that, but I have heard no sign of it in your words. Nevertheless, I agreed to make a voyage longer than any that has been made in recorded history to help solve your problem. You had told me how badly you needed the knowledge; none of you appeared to think that I might want the same thing, though I asked time and again for just that when I saw one or another of your machines. You refused answers to those questions, making the same excuse every time. I felt, therefore, that any way in which I could pick up some of the knowledge you people possess was legitimate. You have said, at one time or another, much about the value of what you call 'science,' and always implied was the fact that my people did not have it. I cannot see why, if it is good and valuable to your people, it would not be equally so to mine.

"You can see what I am leading up to. I came on this voyage with exactly the same objective in my mind that was in yours when you sent me; I came to learn. I want to know the things by which you perform such remarkable acts—things which would be good for me from a selfish point of view—I do not deny that—and which would also help my people. You, Charles, lived all winter in a place that should have killed you at once, by the aid of that science; it could make as much difference in the lives of my people, I am sure you will agree.

"Therefore I offer you a new bargain. I realize that my failure to live up to the letter of the old one may make you reluctant to conclude another with me. That will be simply too bad; I make no bones about pointing out that you can do nothing else. You are not here; you cannot come here; granting that you might drop some of your explosives down here in anger, you will not do so as long as I am near this machine of yours. The agreement is simple: knowledge for knowledge. You teach me, or Dondragmer, or anyone else in my crew who has the time and ability to learn the material, all the time we are working to take this machine apart for you and transmit the knowledge it contains."

"Just a—"

"Wait, chief." Lackland cut short Rosten's expostulation. "I know Barl better than you do. Let me talk." He and Rosten could see each other in their respective screens, and for a moment the expedition's leader simply glared. Then he realized the situation and subsided.

"Right, Charlie. Tell him."

"Barl, you seemed to have some contempt in your tone when you referred to our excuse for not explaining our machines to you. Believe me, we were not trying to fool you. They are



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complicated; so complicated that the men who design and build them spend nearly half their lives first learning the laws that make them operate and the arts of their actual manufacture. We did not mean to belittle the knowledge of your people, either; it is true that we know more, but it is only because we have had longer in which to learn.

"Now, as I understand it, you want to learn about the machines in this rocket as you take it apart. Please, Barl, take my word as the sincerest truth when I tell you first that I for one could not do it, since I do not understand a single one of them; and second, that not one would do you the least good if you did comprehend it. The best I can say right now is that they are machines for measuring things that cannot be seen or heard or felt or tasted—things you would have to see in operation in other ways for a long time before you could even begin to understand. That is not meant as insult; what I say is almost as true for me, and I have grown up from childhood surrounded by and even using those forces. I do not understand them. I do not expect to understand them before I die; the science we have covers so much knowledge that no one man can even begin to learn all of it, and I must be satisfied with the field I do know—and perhaps add to it what little one man may in a lifetime.

"We cannot accept your bargain, Barl, because it is physically impossible to carry out our side of it."

Barlennan could not smile in the human sense, and he carefully refrained from giving his own version of one. He answered as gravely as Lackland had spoken.

"You can do your part, Charles, though you do not know it.

"When I first started this trip, all the things you have just said were true, and more. I fully intended to find this rocket with your help, and then place the radios where you could see nothing and proceed to dismantle the machine itself, learning all your science in the process.

"Slowly I came to realize that all you have said is true. I learned that you were *not* keeping knowledge from me deliberately when you taught us so quickly and carefully about the laws and techniques used by the glider-makers on that island. I learned it still more surely when you helped Dondragmer make the differential pulley. I was expecting you to bring up those points in your speech just now; why didn't you? They were good ones.

"It was actually when you were teaching us about the gliders that I began to have a slight understanding of what was meant by your term 'science.' I realized, before the end of that episode, that a device so simple you people had long since ceased to use it actually called for an understanding of more of the universe's laws than any of my people realized existed. You said specifically at one



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point, while apologizing for a lack of exact information, that gliders of that sort had been used by your people more than two hundred years ago. I can guess how much more you know now—guess just enough to let me realize what I can't know.

"But you can still do what I want. You have done a little already, in showing us the differential hoist. I do not understand it, and neither does Dondragmer who spent much more time with it; but we are both sure it is some sort of relative to the levers we have been using all our lives. We want to start *at the beginning*, knowing fully that we cannot learn all you know in our lifetimes. We do hope to learn enough to understand how you have found these things out. Even I can see it is not just guesswork, or even philosophizing like the learned ones who tell us that Mesklin is a bowl.

"I am willing at this point to admit you are right; but I would like to know how you found out the same fact for your own world. I am sure you knew before you left its surface and could see it all at once. I want to know why the *Bree* floats, and why the canoe did the same, for a while. I want to know what crushed the canoe. I want to know why the wind blows down the cleft all the time . . . no, I didn't understand your explanation. I want to know why we are warmest in winter when we can't see the sun for the longest time. I want to know why a fire glows, and why flame dust kills. I want my children or theirs, if I ever have any, to know what makes this radio work, and your tank, and some day this rocket. I want to know much —more than I can learn, no doubt; but if I can start my people learning for themselves, the way you must have —well, I'd be willing to stop selling at a profit."

Neither Lackland nor Rosten found anything to say for a long moment. Rosten broke the silence.

"Barlennan, if you learned what you want, and began to teach your people, would you tell them where the knowledge came from? Do you think it would be good for them to know?"

"For some, yes; they would want to know about other worlds, and people who had used the same way to knowledge they were starting on. Others—well, we have a lot of people who let the rest pull the load for them. If they knew, they wouldn't bother to do any learning themselves; they'd just ask for anything particular they wanted to know—as I did at first; and they'd never realize you weren't telling them because you couldn't. They'd think you were trying to cheat them. I suppose if I told anyone, that sort would find out sooner or later, and . . . well, I guess it would be better to let them think I'm the genius. Or Don; they'd be more likely to believe it of him."

Rosten's answer was brief and to the point.

"You've made a deal."



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## XX.

A gleaming skeleton of metal rose eight feet above a flat-topped mound of rock and earth whose sides were dotted with curved plates of similar material and various weirdly complex assemblies that might have been vital organs of the glittering monster that was being dismembered. Mesklinites were busily attacking another row of plates whose upper fastenings had just been laid bare. Others were pushing the freshly removed dirt and pebbles to the edge of the mound. Still others moved back and forth along a well marked road that led off into the desert; those who approached dragging flat, wheeled carts loaded with supplies, those departing usually hauling similar carts empty. The scene was one of activity; practically everyone seemed to have a definite purpose. There were two radio sets in evidence now, one on the mound where an Earthman was directing the dismantling from his distant vantage point and the other some distance away.

Dondragmer was in front of the second set, engaged in animated conversation with the distant being he could not see. The sun still circled endlessly, but was very gradually descending now and swelling very, very slowly.

"I am afraid," the mate said, "that we will have serious trouble checking on what you tell us about the bending of light. Reflection I can understand; the mirrors I made from metal plates of your rocket made that very clear. It is too bad that the device from which you let us take the lens was dropped in the process; we have nothing like your glass, I am afraid."

"Even a reasonably large piece of the lens will do, Don," the voice came from the speaker. It was not Lackland's voice; he was an expert teacher, he had found, but sometimes yielded the microphone to a specialist. "Any piece will bend the light, and even make an image—but wait; that comes later. Try to find what's left of that hunk of glass, Don, if your gravity didn't powder it when the set landed." Dondragmer turned from the set with a word of agreement; then turned back as he thought of another point.

"Perhaps you could tell what this 'glass' is made of, and whether it takes very much heat? We have good hot fires, you know. Also there is the material set over the Bowl—ice, I think Charles called it. Would that do?"

"Yes, I know about your fires, though I'm darned if I see how you do burn plants in a hydrogen atmosphere, even with a little meat thrown in. For the rest, ice should certainly do, if you can find any. I don't know what the sand of your river is made of, but you can try melting it in one of your hottest fires and see what comes out. I certainly don't guarantee anything, though; I simply say that on Earth and the rest of the worlds I know ordinary sand will make a sort



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of glass, which is greatly improved with other ingredients. I'm darned if I can see either how to describe those ingredients to you or suggest where they might be found, though."

"Thank you; I will have someone try the fire. In the meantime, I will search for a piece of lens, though I fear the blow when it struck left little usable. We should not have tried to take the device apart near the edge of the mound; the thing you called a 'barrel' rolled much too easily."

Once more the mate left the radio, and immediately encountered Barlennan.

"It's about time for your watch to get on the plates," the captain said. "I'm going down to the river. Is there anything your work needs?"

Dondragmer mentioned the suggestion about sand.

"You can carry up the little bit I'll need, I should think, without getting the fire too hot; or did you plan on a full load of other things?"

"No plans; I'm taking the trip mainly for fun. Now that the spring wind has died out and we get breezes in every old direction, a little navigation practice might be useful. What good is a captain who can't steer his ship?"

"Fair enough. Did the Flyers tell you what this deck of machines was for?"

"They did pretty well, but, if I were really convinced about this space-bending business, I'd have swallowed it more easily. They finished up with the old line about words not really being enough to describe it. What else beside words can you use, in the name of the Suns?"

"I've been wondering myself; I think it's another aspect of this quantity-code they call mathematics. I think it's something for the next generation, myself, though they insist we use some of it in our navigation and the philosophers used more when they found the curvature of Mesklin. I like mechanics best myself; you can do something with it from the very beginning." He waved an arm toward one of the carts and another toward the place where the differential pulley was lying.

"It would certainly seem so. We'll have a lot to take home—and some, I guess, we'd better not be too hasty in spreading about." He gestured at what he meant, and the mate agreed soberly. "Nothing to keep us from playing with it now, though."

The captain went his way, and Dondragmer looked after him with a mixture of seriousness and amusement. He rather wished that Reejaaren were around; he had never liked the islander, and perhaps now he would be a little less convinced that the *Brée's* crew was composed exclusively of liars.

That sort of reflection was a waste of time, however. He had work to do. Pulling plates off the metal monster



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was less fun than being told how to do experiments, but his half of the bargain had to be fulfilled. He started up the mound, calling his watch after him.

Barlennan went on to the *Bree*. She was already prepared for the trip, two sailors aboard and her fire hot. The great expanse of shimmering, nearly transparent fabric amused him; like the mate, he was thinking of Reejaaren, though in this case it was of what the interpreter's reaction would be if he saw the use to which his material was being put. Not possible to trust sewn seams, indeed! Barlennan's own people knew a thing or two, even without friendly Flyers to tell them. He had patched sails with the stuff before they were ten thousand miles from the island where it had been obtained, and his seams had held even in front of the valley of wind.

He slipped through the opening in the rail, made sure it was secured behind him, and glanced into the firepit, which was lined with metal foil from a condenser the Flyers had donated. All the cordage seemed sound and taut; he nodded to the crewmen. One heaped another few sticks on the glowing, flameless fire in the pit; the other released the moorings.

Gently, her forty-foot sphere of fabric bulging with hot air, the new *Bree* lifted from the plateau and drifted riverward on the light breeze.

THE END

# THE THREE LAWS OF STUPIDYNAMICS

First Stupidity Theorem: The probability of predicting correctly in total ignorance is zero.

Second Stupidity Theorem: The only thing you can learn is something you don't know.

Third Stupidity Theorem: You can't tell a man something he doesn't understand and expect him to make use of it.

Thanks to Dr. Wayne Batteau, Harvard Speculative Society.



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## BY P. SCHUYLER MILLER

### MAN, THE IMPROBABLE

It is an odd coincidence that the grandsons of two of the great Nineteenth Century evolutionists should almost simultaneously have produced books bearing on the future of Mankind on this planet. Julian Huxley, author of "Evolution in Action" (*Harper, New York. 1953. 182 pp. $2.75*), is the grandson of Thomas Huxley and is himself a biologist of note. Sir Charles Galton Darwin, whose book is "The Next Million Years" (*Doubleday, New York. 1953. 210 pp. $2.75*), is the grandson of the great author of "The Origin of Species" and is a nuclear physicist.

Both books, slim as they are, are a storehouse of unexplored raw material in the way of themes and ideas for science-fiction writers. They complement each other, Huxley reaching back to the beginnings of the universe and tracing the threads which have brought about the evolution of Man and his societies, while Darwin projects the present over a million future years. Both men consider the human race as Earth-bound: neither looks upon the planets as a release.

It is the biologist who sees hope for Man, the physicist who sees little or none.



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As might be surmised from its title, the greater part of Julian Huxley's little book deals with the process and history of evolution, with Man its latest, highest, and he believes final product—a culmination of improbabilities which it has taken two billion years of mutation and natural selection to produce. The trend, he points out, has been clear from the beginning: only a creature like Man could be what and where Man is.

"Conceptual thought," Huxley points out, "could only have arisen in an animal as against a plant; in a multicellular animal; in an actively feeding animal, with bilateral symmetry and a head; in one with a highly differentiated bodily organization, which was therefore doomed to die; in a vertebrate as against a mollusk or an arthropod; in a land vertebrate as against a fish; and among land vertebrates, only in a placental mammal with a constant temperature. And finally, it could have arisen only in a mammal which had become gregarious, which had a long period of learning and experience, which produced only one young at a birth, and which had recently become terrestrial after a long spell in the trees." This necessary ladder of development is the evolutionary history of Man. No other species, Huxley insists, can supplant him as the dominant species on Earth —unless that species develops from Man himself. And that development will be as slow as Man's own separation from the lower primates.

But, says Huxley, with Man we come to a new phase in revolution, just as with the beginning of life the biological phase supplanted the purely astrophysical. Man is an animal with a society—a culture—and that culture also evolves and makes *Genus homo* better and better able to control himself, his world, and his destiny. "Man is the result of two thousand million years of biological evolution," Huxley says; "he has every prospect of an equal or even greater span of psychosocial evolution before him. The human species has many grave problems before it: but it has a great deal of time in which to work them out."

"Not so!" says Sir Charles Darwin: "Man will have multiplied out of house, home and food within twenty thousand years—in all probability in less than two thousand." And his arguments—an extension of the old Malthusian principle that Man is multiplying at an exponential rate while his food supply can increase only in arithmetic progression—seem all too reasonable.

What is also of interest, some of our better science-fiction writers seem to have arrived at some of his principles independently.

Nothing, fundamentally, can evade the eventual starvation-balance of the human race, Sir Charles insists. We may come into still other temporary "golden ages" when food supply and hungry stomachs are in balance



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through the release of some unsuspected form of energy, or some revolution in food production, but these will be fleeting. With the overrunning of the Western Hemisphere Man lost his last chance to get something for nothing through the exploitation of untouched fertile soil.

Darwin sees a future of dog-eat-hungry-dog, when all the world will be reduced to the starvation economy of India or China, when local quirks of history may produce enough surplus to permit the luxury of temporary democracy, but when most of the world will be fragmented into jealous, hungry, warring oligarchies of one kind or another. If a new species arises out of Man in a million years—and here it seems to me that Sir Charles overlooks the fact that half of that million have already elapsed since Man was born—it may find some new basis for survival, but there is small hope until then.

Man is and will continue to be a "wild" animal, Sir Charles argues. By this he means that there is no outside "master" to direct human selective breeding toward ends of maximum efficiency: a ruling group can perhaps force such a pattern on the rest of the race, but cannot objectively improve its own stock. In this, I think, Huxley would concur with the added point that this very wildness is the salvation of the race—since it means a continued shuffling and sorting of genes, a continued amalgamation of small change mutations, and the continued operation of natural selection to strengthen combinations which have survival value.

This theme of a dominating, directing aristocracy which must be kept wild is precisely the theme of John MacDonald's "Ballroom of the Skies" (Greenberg, $2.75).

Sir Charles makes several interesting suggestions with science-fictive possibilities. He suggests that as the agricultural revolution of some eight or ten thousand years ago gradually produced a type of man adapted to agriculture, enjoying it, and living for it, so the later urban revolution is even now producing an urban man who cannot be happy except in cities—and our recent scientific revolution may eventually (if Man survives) produce a scientific man, to whom scientific thinking comes naturally.

There are three ways in which a leader can force any policy of betterment on the world, Sir Charles says. Political control is likely to live only so long as he remains alive or in power. It may be possible to change Man's nature biologically, but the chances are that it will take too long for any one man or dynasty of men to accomplish. The third, and hopeful way, is through a creed—a religion like Christianity, a political philosophy like Communism, a taboo such as is found in many celibate groups—which enlists a large enough sector of humanity for a long enough time (Darwin sug-



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gests two centuries as a round average based on past experience) to directly change the nature of human society and the lives of a large part of the world.

And this is another theme which science fiction is using currently. In "The Space Merchants," by Frederik Pohl and C. M. Kornbluth, scheduled for publication by Ballantine in joint paper-back and hard-cover editions on May 18th, we have a future society in which the "Connies" (Conservationists) are a fanatical, dedicated, underground creed corresponding to the Commies of today.

Sir Charles suggests the past history of China as a model of the probable history of the future. He believes that Man will evolve a procreation drive—a drive to have children and perpetuate the race—stronger than the present sex drive, and that the sector of the race which develops it first will swamp out the rest of Mankind. Conversely, any sector which does *not* develop it—as among the more prosperous classes of Europe and America—will be themselves run under.

Let me quote Sir Charles' picture of this Sinicized future of mankind, and then commend the two books to you:

"The regions of the world will fall into provinces of everchanging extent, which most of the time will be competing against one another. Occasionally . . . they will be united by some strong arm into an uneasy world-government, which will endure for a period until it falls by the inevitable decay that finally destroys all dynasties. There will be periods when some of the provinces relapse into barbarism, but all the time civilization will survive in some of them. It will survive because it will be based on a single universal culture, derived from the understanding of science; for it is only through this understanding that the multitudes can continue to live. On this basic culture there will be overlaid other cultures, often possessing a greater emotional appeal, which will vary according to climate and race from one province to another. Most of the time and over most of the earth there will be severe pressure from excess populations, and there will be periodic famines. There will be a consequent callousness about the value of the individual's life, and . . . cruelty to a degree of which we do not willingly think. On the other side there will be vast stores of learning, far beyond anything we can now imagine, and the intellectual stature of man will rise to ever higher levels. And sometimes new discoveries will for a time relieve the human race from its fears, and there will be golden ages, when man may for a time be free to create wonderful flowerings in science, philosophy and the arts."

And Julian Huxley:

"Once the fact is grasped that we men are the agents of further evolution, and that there can be no action higher or more noble than raising the



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inherent possibilities of life, ways and means will somehow be found for overcoming any resistances that stand in the way of that realization. . . Human history and human destiny are part of a larger process. Only by getting some over-all view of reality, in its dual aspect of self-transforming pattern and continuing process, can man hope to get a clearer view of his place—his unique place—in the process, and steer a better course into the future."

Did someone page Hari Seldon?

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**SPACE SERVICE, edited by Andre Norton. World Publishing Co., Cleveland. 1953. 277 pp. $2.50**

Andre Norton—*Miss* Norton, as I have belatedly discovered after doggedly miscalling her for two years—has twice put herself in the debt of science fiction fans: first for editing Malcolm Jameson's "Bullard" stories into a neat whole, then with her own nicely written "Star Man's Son." These were allegedly for teen-age readers, but like the Heinlein "Juveniles" were good reading for anyone.

"Space Service" now offers young readers ten stories whose heroes represent ten branches of service in the galactic civilization of the far future. All but two came originally from this magazine: you liked them then, and you'll like them still in a book which has the peculiarity of juvenile books that it costs about one dollar less than the same book would if published for an adult audience.

Read as a collection of stories which introduce new, young enthusiasts to the ranking concepts of life in space, "Space Service" has the drawback that the picture is wholly male and wholly military. The exceptions—weak ones—are H. B. Fyfe's "Implode and Peddle," a Bureau of Slick Tricks yarn which takes place in a thoroughly military setting, Bernard Kahn's "For the Public," which shows a quarantine doctor tangling with political influence, Dr. Joseph Winter's "Expedition Polychrome," another medical problem (the one in which a spaceman turns bright blue—remember?), Raymond Z. Gallun's "Return of a Legend," in which human pioneers on Mars become Martians in their own right, and C. M. Kornbluth's "That Share of Glory," which will be remembered as the story about a semireligious brotherhood of galactic Heralds, professional interpreters and students of what Sprague de Camp would call Xenology. No services for women, and few for peace.

Kahn and Fyfe are here twice: Kahn with Nord Corbett, Space Ship Commander, facing the problem of the infected chlorophyll tanks in "Command" and Fyfe with "Star-Linked," in which Galactic Communications Officer Harry Redkirk keeps his fingers on the pulse of the galaxy. This last, I'll have to admit, is definitely a peaceable story and one of the



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best in the collection.

Then there's Ben Harlow, Space Steward, in Walt Sheldon's "Chore for a Spaceman"—a bit on the second-string level—and Theodore Cogswell's "The Specter General" with Space Marine Kurt Dixon, in one of the best yarns ASF has had in some time and the best in this book. Gordon Dickson's "Steel Brother," with its Frontier Guard mentally linked with the memories of his predecessors, is another that doesn't seem up to the rest of the book. But taken as a whole, it's good stuff, selected by someone who knows her business and will do a lot to steer neophytes away from trash and toward sound values in their science-fiction reading.

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**PRISONER IN THE SKULL, by Charles Dye. Abelard Press, New York. 1952. 256 pp. $2.50**

The place which Abelard Press earned by breaking into the science-fiction publishing race with "Outpost Mars" it has promptly lost with "Prisoner in the Skull."

The theme is good, but was done better in James Blish's "Jack of Eagles." The two books suffer from the same fault: a rapid collapse into unbelievable—as opposed to believable—melodramatics.

Alister Conrad, business executive of the year 2000, wakes up in the woods of New Jersey with a lost memory. He televises his wife, who screams—and disappears. He is gassed, taken to Unesco headquarters, and enlisted by the beautiful directress of World Education, Val von Rachin, to find and kill the world's only telepath—one René de Lamiter. Then the action begins to grow fast—and confusing.

The slaughter which follows Conrad's search for his past and for de Lamiter would make a hard-boiled private-eye yarn of the ultra-Spillane school look pallid. Indeed, a private eye named Dave Kyle is an early victim, along with Conrad's wife, mistress, and assorted bystanders. Who is fighting with or against whom in this hapless chase, which finally takes Conrad to the Moon, is anyone's guess but never plausible. It's old-fashioned hunt-and-chase, as the jacket says, but neither good detective fiction nor good science fiction.

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**THE LEGION OF TIME, by Jack Williamson. Fantasy Press, Reading. 1953. 252 pp. $3.00**

Fifteen years ago the twin influences of A. Merritt and Edmond Hamilton were hanging over science fiction—who influenced *them* it is a little harder to see. Young writers, just discovering science fiction and trying their own hand at it, were doing their level best to be as colorful in their concepts as Merritt, as space-seeping as Hamilton. If worlds were tossed at each other with abandon, as they usually were, then the worlds



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were brightly colored and had planets with rings.

Jack Williamson and Henry Kuttner—not to mention C. L. Moore—were among the few of these derivative youngsters who survived and developed individuality of their own. And when one of their older tales, like Williamson's "Legion of Space" and "Cometeers" or the present "Legion of Time," is resurrected today, it is easy to see why the author has survived: he tells a story well.

You won't find social values or lasting prose in the two Williamson operas of 1938 vintage in this new book, but if you like simple space-and-time action maybe you'll find them good entertainment. In the title story a time-ship loaded with dead heroes voyages forth to try to save the probability-world of Jonbar, with its beautiful, good Lethonee, from being pushed into nonexistence—or rather total improbability—by beautiful, *bad* Sorainya of Gyronchi. In the second tale, "After World's End," Barry Horn, first space explorer, is hurled into a state of suspended animation which brings him back to consciousness millennia later, when the mechanical race his namesake-descendant created is trying to exterminate mankind.

In both stories are the familiar elements which were part of the Merritt formula—the fated hero around whose actions the universe spins, the mystical talisman—the


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black brick of Gyronchi, the diamond block of Malgarth—the little company of born-to-die fighters. But there was and is a color about it all that seems to have gone out of much of modern science fiction and into the drum-and-strumpet costume novels.

If you remember the science fiction of the '30's with fond nostalgia, maybe you'll want to look at these again. If you've never read any of it, these two yarns are representative. But will someone please tell me where Richard Angerman's jacket illustration fits into either story?

---

**STARS IN THE MAKING, by Cecilia Payne-Gaposchkin. Harvard University Press, Cambridge, Mass. 1952. 160 pp. + xii. 67 plates. $4.25**

Since things of space are still and probably always will be one of the prime considerations of science fiction, we try in this department to keep abreast of the new, seemingly good, and comprehensible books of cosmogony. Probably a specialist like Richardson should be reviewing them: certainly constructive criticisms pointing out that I know not whereof I speak will be welcome.

The latest of these looks to this layman like one of the best. It is one of the admirable series of Harvard Books on Astronomy (which were amazingly remaindered in the drugstores a few years ago by their original publisher, and have now been tucked under the Harvard wing—at nearly double the original price). In it Dr. Payne-Gaposchkin, Phillips Astronomer at Harvard, adds up the conclusions she has reached in twenty-five years of studying the stars.

"Stars in the Making" is at the same time less detailed and comprehensive than Gamow's "Creation of the Universe," and more up-to-date and thorough. Where Gamow—like Hoyle—tends to present every problem as solved in principle—if not quantitatively or in detail—Dr. Payne-Gaposchkin frankly points to the holes in the pattern and notifies us when she is going out on a personal limb which others of her colleagues are diligently trying to saw off.

The author's method is to marshal the evidence, piece by piece, then in her final chapters fit it together into a seemingly consistent pattern of evolution from dust to galaxies. We are first introduced to the Sun as our nearest and easiest-to-study star, then taken into the company of other and stranger stars. We are shown individual stars, with all their inconsistencies of appearance and behavior, instead of categories—indeed, the spectral types are never mentioned as such. We are taken into the great dust clouds which seem to hold as much matter as all the stars together—then in a second section go on to look at the various star-systems in our galaxy and outside, from simple doubles to



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the great island universes like our own (only recently reported by Shapley to be twice as far away as we had supposed). Finally, the bits of evidence are put together, the players come on stage, and the drama of the evolving universe is played before us.

"Stars in the Making" seems to be about as close-to-date as a book well can be, given the delays of publication. Much of the information in it comes from direct communications between the author and other astronomers. Here, for the first time in a book for general readers, is the story of Baade's great discovery of the two families of stars: Population I in the flattened disk of the galaxy, whirling in orbits about its center, accompanied by the vast dust clouds from which new stars are born and by the hot, blue, young "spendthrift" stars; Population II with its swarm of globular clusters distributed in a gigantic globe of globes, and its cool, red, old giants, beating about in seemingly random motion. Morgan's tremendous success in photographing part of the spiral arms of our own galaxy, announced only about a year ago, is mentioned.

What raw material for galactic rovers! In this view, the stars in the center of the galaxy are much older than those in our region. They have had time to build up great civilizations, and their roving orbits are continually carrying them out among the young systems of the galactic arms.


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And on the larger scale we see whole galaxies colliding and interpenetrating —sweeping out each other's dust clouds and nebulae, stopping each other's evolution short.

One complaint I have, from a writer's point of view. There are a number of text figures in addition to the excellent plates. Most of them show graphically the complex relations among members of multiple star systems—grand settings for stories—but most inconsiderately Dr. Payne-Gaposchkin has not told us—in most cases—which stars they are. For that, presumably, one must hunt up her original study—but it would have been so easy to add a few names. As the barkers insist all up and down Broadway, "Without the program ya can't tell the actors."

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**THE PETRIFIED PLANET. Twayne Publishers, New York. 1953. 263 pp. $2.95**

The "petrified planet" of the title in this Twayne "Triplet" is Uller, second planet of Beta Hydri, whose life-forms have evolved around a silicone metabolism, assimilating assorted minerals and excreting them as $CO_2$, $H_2O$ and silica armor. It has a neighbor, Niflheim (Nu Puppis IV) with a fluorine economy. Both were invented for the occasion, and described in considerable detail, by Dr. John D. Clark, who lives at being a chemist but once sank so low as to sell two stories to this magazine in 1937 and to work out a biography of Robert E. Howard's utterly unscientific hero, Conan.

Three skilled writers have then built stories around the chemistry of these two worlds: Fletcher Pratt in "The Long View," H. Beam Piper in "Uller Uprising," and Judith Merril in "Daughters of Earth." The first two stories appeared in current magazines, while the book was in press. If the third did, I missed it, though it's the best of the three.

It may bother you, as it did me at first, that the three haven't agreed on a common background aside from Dr. Clark's chemistry and astronomy. For their Ullers are three entirely different worlds where the book might have shown us three episodes in the history of one and the same planet. Still, that wasn't the problem.

Actually, "Daughters of Time" places first, chronologically. Simply and gently it tells, through the memories of one of them, how a family of women have gone into space—Joan to Pluto, her granddaughter Emma to Uller, her granddaughter Carla to Niflheim—and how in alternate generations other women have lived the bitter unhappiness of being temperamentally planet-bound: Martha on Earth, Ariadne on Pluto, Lee on Uller. It adds up to a story which does for space pioneering what Conrad Richter's simple trilogy, "The Trees," "The Fields" and "The Town," does for the American frontier.



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"The Long View," first in the book, takes up the story a little later when Uller and its handful of colonists are a piece in the political maneuvering of a complex Terrestrial society. Shenanigans are the order of the day here—with the suspected resources of unexplored Niflheim the key to the puzzle-lock.

"Uller Uprising" is almost novel-length in itself, and deals with a third Uller still later in history, when mines have been opened on Niflheim. Judith Merril had rather simple, alien Ullerians; Fletcher Pratt keeps his elementary and predacious; but H. Beam Piper, for the sake of some out-and-out thud-and-blunder, r'ars his up on the last pair of their six legs, gives them a feudal society with a plethora of local monarchs, and sends an earnest young (female) social worker from Earth to investigate the horrible way in which the poor dumb natives are being exploited by the Uller Company and its industrial imperialists.

Piper has adopted the late Talbot Mundy's engaging trick of informal, conversational chapter headings ("Rakkeed, Stalin, and the Rev. Keeluk," "Four-and-Twenty Geek Heads," "Bismillah! How Dumb Can We Get?") and the whole story has the air of a space-transported Mundy yarn of the white-man's-burden in India transported to Uller and the opal-grinning geeks—with noble Kragans instead of noble Sikhs. It's outrageous space opera, but it's fun.

Try it again some time, Twayne.

THE END



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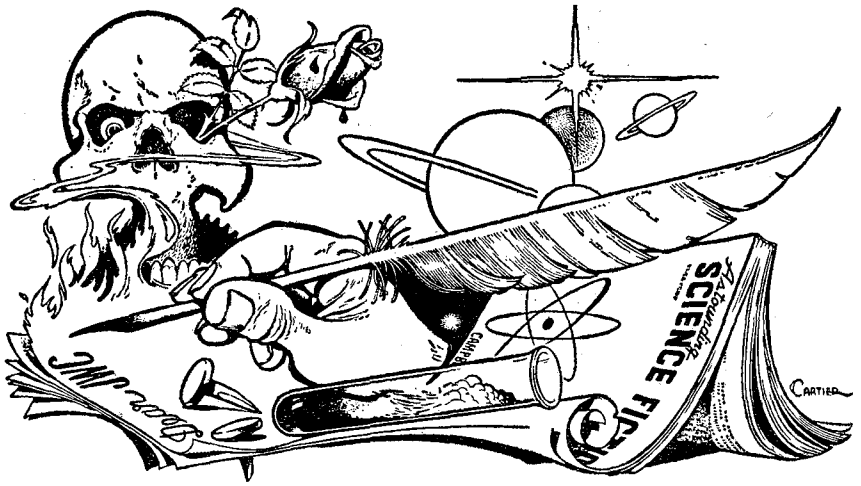


# BRASS TACKS

Dear Mr. Campbell:

As an illustration of one of the ideas in Jones' story "Noise Level," I would like to describe how anyone can, in a few minutes, construct a learning device based on the noise filter principle. This device, a modification of Dr. Shannon's maze-solving mechanical Mouse, consists of a paper maze, a penny, and a deck of cards, and clearly demonstrates the random source and filter, and how they work. I will first describe how to construct a Mouse Analogue with no noise source or filter, which follows to some extent the same rules as the electric relays of Shannon's Mouse.

Draw with a fine-line pen a 7¼ inch square consisting of twenty five 1½ inch squares, marking any small square START, and any other small square CHEESE. By tracing heavy ink lines over some of the 1½ inch sections of fine lines, construct a maze having exactly one path from START to CHEESE, and numerous blind alleys. Heavy lines denote walls, the fine lines representing openings from one square to the next, through the sides of the squares. All sides of the large square should be in heavy ink.

Place a penny (the mouse) "tails up" in the center of the START square, and move it according to these rules:

(1) The penny can move only



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North, East, South, or West, these directions being parallel to the ink lines.

(2) It may change its direction of motion only at a wall or at the center of a square.

(3) On meeting a wall, it must return to the center of the square containing the wall.

(4) The center of the penny should always be followed with a pencil trace, and when the penny meets a wall, the trace should be extended to the wall and back to the center of the penny. Double lines should be separated slightly.

(5) The penny avoids following any pencil line unless forced by a wall, or by convergence of pencil lines from all four directions.

(6) If a penny at the center of a square can, under rule (1), leave without following a pencil line, it prefers N, E, S, W, in that order, moving in the first of these directions permitted by rule (5). Hence, the first direction by which it leaves the center of the START square is North, even when the square has a wall in this direction.

(7) If the penny is in a square with pencil lines converging from all four directions, it follows the direction of the single line, avoiding double lines.

(8) When it reaches the square marked CHEESE, return it to the START square, and turn it "heads up." Erase all double pencil lines, and cover the remaining pencil line with a heavy ink line.

(9) Rule (6) applies only to a "tails up" penny. If "heads up," the penny follows the ink trail, and as before, its progress is traced with a pencil; it moves in the direction along the ink trail that avoids the pencil line. When it reaches CHEESE, it is returned "heads up" to the START square, and all pencil marks are erased.

When the penny is "tails up" the process it follows will be called "exploration," while the "heads up" process will be called "tracking." The pencil mark may be thought of as a scent the penny leaves of itself. According to the above rules, the *exploring* penny avoids following trails of scent if it can; but if it cannot travel a scent-free path, it chooses the *oldest* scent. The *tracking* penny always tracks the *freshest* scent. The pencil line may also be thought of as symbolizing the stream of consciousness, carried in the memory, rather than on the maze. Neither the operator's knowledge of the maze nor his memory of the previous behavior of this Mouse Analogue can influence the action of the Analogue.

A random element is introduced by replacing the exploration preference order of N, E, S, W with a random pattern determined by a pack of bridge cards, and by replacing automatic tracking with a random tracking process based on the same pack of cards. For the random exploration, let *spades* mean N, *hearts* E, *diamonds*



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S, and *clubs* W. When the penny reaches the center of a square, cards are drawn and the penny is moved according to the first card that indicates a direction consistent with rules (5) and (7).

For the *first* random tracking move, draw a card to indicate direction; then draw another card. If this second card is *not* a spade, ignore the first card, and let tracking occur as in rule (9). If the second card *is* a spade, the penny is turned "tails up," and a small X is inked in a corner of the square; the penny now performs random exploration, leaving the center of the square according to the *first* card. When it returns to the ink line, it is again turned "heads up." Since rules (5) and (7) apply only to pencil lines, exploration may begin in the direction of the ink line; in this case, the penny is turned "heads up" at once.

This procedure is followed for *any* move of a "heads up" random penny, with two modifications: (a) The *ace* of spades becomes the condition for exploration from squares already containing an X. No further X's are marked in such squares. (b) If the first card indicates a direction along a pencil line, draw more cards until a direction with no pencil line is indicated. It is the latter direction that is chosen, if the next card satisfies the condition for exploration.

Learning occurs as more and more squares are marked with X, since there is far less chance of leaving the ink line from squares so marked. One may plot the number of inches traveled each time from START to CHEESE against the number of times the penny has begun this journey, and if a series of such plots are averaged, the resulting learning curve should smoothly decrease. The random element endows the penny with "free will," while the random tracking increases the penny's learning time, to yield learning curves more typical of animal behavior. The random element in the exploration process does not alter the average learning time; but makes it *possible* for the penny to avoid all blind alleys the first time through *any* maze, this not being the case for the non-random penny.

What about the noise source and noise filter? The penny has, at most, four possible outputs at any instant—N, E, S, W. So pure noise is a random sequence of these directions, and the noise source is represented by all cards that *indicate* one of these directions. When each of the four outputs is equally likely, there is no noise filter; but if a choice at a certain point has led back to that point without leading to CHEESE, the noise filter cuts in, acting to prevent recurrence of the same unrewarding choice. Or if some route has led to CHEESE, the filter acts to exclude all directions except along this route. The noise filter is the application of rules (5), (7), or (9), and is based on trial and error. It is in



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every sense a filter; *the noise source initiates every impulse conceivable to the penny, but only those not rejected by the filter affect the penny's behavior.* However, the random element in the tracking process allows only tentative action by the filter.

How does this process correspond to human thought? Man has more than four possible outputs at any instant but very likely a finite number, having a finite number of neurons that can each do only two things—fire or not fire. As he develops, certain activities of which he is muscularly capable become excluded from his behavior as a result of trial and error. But, generally, as in the case of the random penny, there are choices he can make at any instant, such that the one he will choose is not rigidly predictable.

The maze might represent a problem in mathematics, the choice of turns involving which mathematical operation to try next. If we perform a series of operations only to return to a previously employed expression, we do not normally repeat the circularity. If there is still an untried procedure, we try it, and if not, we retrace our steps and look for one farther back in the string of computations. If we solve the problem, we might forget the solution, and blunder into blind alleys in trying to re-solve it. But eventually our noise filter may exclude all but the proper path.

Another reason for deviating from a path that leads to a satisfactory result is the hope of finding a better result, whether by a dog with a bone who thinks he sees a bigger bone, or a man with a theory who hopes to find a better theory.

As pointed out by Dykstra, even noise filters can go wrong; minor successes often block the way to great achievements. As one justification for the tentative nature of the noise filter,



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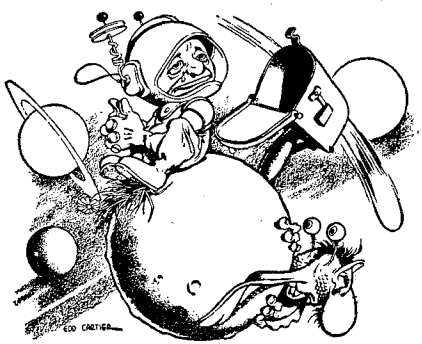
consider this example!

Suppose one maze square were marked CHEESE and one marked BREAD, each having only one opening. Let us stipulate that if the penny finds BREAD first, it is turned "heads up" and rules (8) and (9) apply as if CHEESE had been found, except that the trail to be inked from START to BREAD is dotted. But if it ever reaches CHEESE, the penny is marked with a piece of adhesive tape (as memory) and a *full* ink line is drawn over the *single* pencil trace, dotted lines losing all significance. Then, if a penny with *automatic* tracking reached BREAD before reaching CHEESE, it would never find the latter (contending there can be no revision of the postulate that the BREAD path is correct). But a penny with *random* tracking will eventually find CHEESE, then will tend to follow the direct CHEESE path, not being cheated of CHEESE by finding BREAD.

I would now like to criticize a statement by Mr. Mollenhauer in the July Brass Tacks. He says, "A machine can be made to compute, not think, for true thought is creative and purposeful." I suggest that the random penny device is both creative and purposeful.

"Creative" might be defined in terms of *an output which is not entirely determined by the inputs*. The inputs may cause the random penny to be "heads up" or "tails up," to wear adhesive tape, or to occupy a square which contains various pencil and ink lines. But while the next output is influenced by these factors, it is generally not entirely determined by them. When the penny turns from a well traveled path between START and BREAD, and moves toward undiscovered CHEESE, *that* is creative.

In general, "purpose" is characterized objectively by a tendency toward *exploration* before a certain input (the goal) has been received or any method for producing it discovered, and by a tendency, after reception of the input, to *reproduce* behavior that closely preceded the input. By this criterion, the *non-random*



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penny has the purpose of finding CHEESE. After finding CHEESE, it repeats the behavior which at each decision point—center of each square —most closely preceded the attainment of this goal. The final version of the *random* penny exhibits the multipurpose behavior of seeking BREAD and CHEESE, and in general of always seeking a better way of life than the one it has found. Hence, the purpose of returning to BREAD may conflict with the purpose of finding an even better life, forcing a compromise on how much effort should be spent in attaining a "goal in the hand," and how much in hope of attaining higher "goals in the bush."

For a description of Dr. Shannon's Mouse, see CYBERNETICS, Transactions of the Eighth Conference, March 15–16, 1951, Josiah Macy, Jr. Foundation, 565 Park Ave., New York City.—Robert J. Lee, 541 Lahoma, Norman, Oklahoma

Dear John:

Enclosed is Mr. Lee's letter on maze-solving—I thought it a well written and interesting note. The penny manipulations are a neat way of explaining and experimenting with various strategies for solving mazes.

The first set of rules are close to but not identical with those used in my maze-solver. At one time I considered a partially random strategy similar to his second set, but abandoned it chiefly because it is rather difficult to trouble-shoot machines containing random elements. It is difficult to tell when such a machine is misbehaving if you can't predict what it should do! Mr. Lee's third strategy with both bread and cheese is a little like a problem-solving maze-runner now being constructed by E. C. Berkeley Associates.—C. E. Shannon



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(*Continued from page 8*)

vanced university laboratories. Mass spectrographs are now offered on an "our catalogue number . . ." basis by a number of firms. Recording electrospectrophotometers are offered for industrial labs, "in gray crackle or other finish. File space for storing recordings or other data built into the cabinet. A handsome piece of equipment in any laboratory."

Yes—the fact that it does automatically, and in a matter of seconds, something advanced university laboratories couldn't accomplish in weeks a few decades ago is not enough; by rights the technician properly holds that it should also be good looking, convenient, and make efficient use of space. Mass spectrographs, on the other hand, are advertised as useful devices for detecting leaks, and for production-line quality control inspection.

Robots are offered by several scores of companies; they aren't tin men, since no one wants a tin man for any valid industrial use, so they're called "automatic process control equipment" or the like—or "digital computer systems." But the computing machine that was, not more than a few years ago, a thing of rare wonder is now a standard catalogue item from dozens of companies. A recent issue of *Scientific American* carried a series of articles on cybernetics—but the advertisements that went with the articles were even more revealing. A popular, newsstand sale magazine carrying advertisements for standard trade devices that would be described only in science-fiction magazines as little as fifteen years ago!

The last batch of commercial catalogues I got from Dr. Pomeroy contains one that is still at least a little bit on the interval-of-wonder boundary. It's from Radiation Counter Laboratories, Inc., of Nucleonic Park, Skokie, Illinois—their "RCL Illustrated Price List No. 12." One of the first items offered, I see, is "A Handbook On Small Research Nuclear Reactors for Universities & Industry," $6.00 a copy (10% discount on 5 copies or more).

Then there's the "Oak Ridge Compensated Ionization Chamber, RCL Mark 17 Model 2," a neutron-sensitive instrument used in pile controls. Outside dimensions 3 feet long, by 3¾ inches diameter. $1,345.

They do not as yet, apparently, have a complete small nuclear reactor installation, with all control equipment and installation costs, offered as a packaged installation as a catalogue item. That may be a year or two more—but not much longer, I imagine.

I can't yet get quotations on that four-man scout ship—but I can, if I want, get quotations on eighty megavolt X-ray equipment, or small atomic power plants.

Of course, we always knew that would happen, didn't we?

THE EDITOR.



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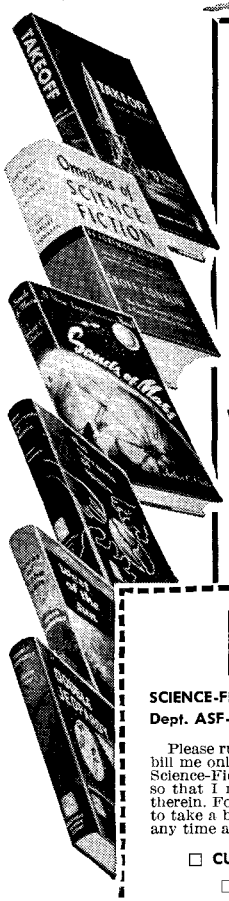


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